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OVERWEIGHT AND OBESITY DEVELOPMENT AND SCHOOL HEALTH CARE INTERVENTIONS OVER PRIMARY SCHOOL YEARS

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OVERWEIGHT AND OBESITY DEVELOPMENT AND SCHOOL HEALTH CARE INTERVENTIONS OVER PRIMARY SCHOOL YEARS

Paula Häkkänen

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I Häkkänen P, Ketola E, Laatikainen T. Development of overweight and obesity among primary school children – a longitudinal cohort study. *Fam Pract* 2016; 33(4):368-373. Doi: 10.1093/fampra/cmw042. Epub 2016 May 26.

II Häkkänen P, Ketola E, Laatikainen T. Screening and treatment of obesity in school health care – the gap between clinical guidelines and reality. *Scand J Caring Sci* 2018; 32: 1332-41. doi: 10.1111/scs.12578.

III Häkkänen P, But A, Ketola E, Laatikainen T. Distinct age-related patterns of overweight development to guide school health care interventions. *Acta Paediatr* 2020; 109(4):807-816. Doi: 10.1111/apa.15036. Epub 2019 Oct 17.

IV Häkkänen P, But A, Ketola E, Laatikainen T. Weight transitions and psychosocial factors: a longitudinal cohort study of Finnish primary school children with overweight. *Prev Med Rep* 2020; 20:101239. https://doi.org/10.1016/j.pmedr.2020.101239. Epub 2020 Nov 5.

ABBREVIATIONS

Avohilmo	The Register of Primary Health Care Visits
BMI	Body mass index
BMI SDS	Body mass index standard deviation score
CI	Confidence interval
COSI	The European Childhood Obesity Surveillance Initiative
EASO	The European Association for the Study of Obesity
EHR	Electronic health record
HBSC	The Health Behaviour in School-aged Children -survey
IOTF	The International Obesity Task Force
IQR	Interquartile range
LCMM	Latent class mixed model
MSM	Multistate model
OKM	Opetus- ja kulttuuriministeriö (Ministry of Education and Culture)
OR	Odds ratio
SES	Socioeconomic status
STM	Sosiaali- ja terveysministeriö (Ministry of Social Affairs and Health)
THL	Terveyden ja hyvinvoinnin laitos (Finnish Institute for Health and Welfare)
USPSTF	The United States Preventive Services Task Force
WHO	World Health Organisation
WOF	World Obesity Federation

ABSTRACT

The objective of this thesis was to analyse obesity screening and treatment practices in school health care, patterns of overweight and obesity development of primary school children, and the associations of psychosocial family- and school-related characteristics to overweight and obesity development.

School health care stands crucial for primary prevention of obesity and offers a natural setting for childhood obesity interventions. Yet, screening and treatment of obesity in primary health care has been revealed to be inadequate and prospective longitudinal studies in unselected populations and in Finland are lacking. Additionally, data on childhood obesity consistency, progress and, especially, resolution remain scarce yet are all fundamental for risk evaluation. Furthermore, targeted prevention and treatment of obesity calls for methods for identifying children with potential to develop obesity without natural resolution.

The study cohort of this longitudinal retrospective register study consisted of 2000 randomly selected primary school sixth graders aged 12-14 who studied in Helsinki in 2013. Of these, using weight-for-height references, 402 children were affected by overweight at least once since their first grade, 172 by obesity, and 1278 held normal weight over primary school. Electronic health record (EHR) data on growth measurements of the 574 children were manually collected for the study. These were enhanced with the entries of their visits at primary health care and from their pre-seventh grade school health checks.

Development of the children's overweight and obesity during six primary school years was explored by 1) comparing weight categories between early-life and primary school age (Study I), 2) utilising flexible latent class mixed models (LCMM) on body mass index standard deviation score (BMI SDS) to explore groups (latent classes) of children with similar weight development (Study III), and 3) applying Markov multistate models to examine rates of transitioning between BMI SDS categories of normal weight, overweight and obesity (Study IV).

Associations of psychosocial family- and school-related factors with weight categories were examined in Study I, and with transition rates in Study IV. School health

care personnel's ability to screen, diagnose and offer overweight-related interventions was analysed in Study II. Whether the actualised interventions were associated with resulting latent classes was investigated in Study III.

Obesity started early in primary school and was fairly consistent. The identified overweight trajectories, five for girls and four for boys, converged around age 10, after which only some continued into obesity. Of the yearly transitions from one weight category to another, the highest 1-year probability for girls was staying in overweight category and for boys in obesity category.

Compared to children with overweight, a larger fraction of children with obesity had experiences of crises or being bullied or had special needs in studying (Study I). Among girls, transitions into obesity were associated with divorced or single parent families, and decreased resolution from obesity was associated with non-native families (Study IV). Among boys, experiences of crises and being bullied were related to obesity development and to decreased resolution from overweight.

Annual nurse assessments actualised well, and school physicians met almost all children with obesity at grade 5 health checks. Of overweight-related extra visits to school physicians, half took place without parents (Study II). Parents accompanied their children at 6% of extra visits to school nurses. Merely a third of the children with obesity received a diagnosis for obesity, even though overweight and obesity were well detected. Overweight-related interventions were mostly offered to children with obesity, less to children of ascendant trajectories (Study III).

Typical overweight development patterns, along with their associations with family- and school-related factors, should be noticed when planning individual treatments or health check programs. By doing so, individual treatments could actualise better, and we could benefit more from the limited resources of school health care. Health check programs should be carefully scrutinised, as one of the conclusions of the study points to potential advantages if extensive health checks at 5th grade were actualised earlier or scheduled more flexibly. Working methods, long-term treatment plans, involvement of parents and diagnosis of obesity were found to be areas requiring development and further studies.

TIIVISTELMÄ

Tämän takautuvan kohorttitutkimuksen tavoitteena oli perusterveydenhuollon potilaskertomuksia hyödyntämällä selvittää miten lasten ylipaino ja lihavuus ala-asteen aikana kehittyvät, miten lihavuuden ennaltaehkäisy ja hoito kouluterveydenhuollossa toteutuvat ja mitkä tekijät kouluterveydenhuollossa tai lapsen elämäntilanteessa näihin vaikuttavat.

Kouluterveydenhuollolla on luonteva asema lasten lihavuuden ehkäisyssä ja lihavuuden hoidon tarjoajana. Kuitenkin perusterveydenhuollossa lihavuuden tunnistaminen ja hoito ovat kansainvälisten tutkimusten mukaan riittämättömiä. Kehittämistyön tueksi tarvitaan lisää eteneviä valikoimattomassa aineistossa toteutettuja pitkittäistutkimuksia niin Suomessa kuin kansainvälisestikin. Myös lihavuuden pysyvyydestä, kehittymisestä ja erityisesti remissiosta tarvitaan lisää tietoa. Jotta hoito osataan kohdistaa niihin lapsiin, joilla lihavuus todennäköisimmin tulisi olemaan pysyvää ja jotka siten hoidosta eniten hyötyvät, on lihavuuden kehittymisen ja ennustetekijöiden tunteminen tärkeää.

Helsingin koulujen 6.lk 12-14-vuotiaista oppilaista keväällä 2013 otetun satunnaisotoksen 2000 lapsesta 574 oli ala-asteen aikana vähintään kertaalleen ylipainoisia (402) tai lihavia (172) kliinisessä työssä käytössä olleen pituuspainomäärityksen perusteella. Lapsista 1278 voitiin luokitella olleen koko kouluiän normaalipainoisia. Näiden 574 lapsen sähköisistä potilaskertomuksista kerättiin takautuvasti taustatietoja, kasvutiedot sekä lihavuuden tunnistamisen ja hoidon kannalta merkitykselliset ala-asteen aikaiset kirjaukset.

Ylipainon kehittymistä tutkittiin 1) vertaamalla keskenään lasten neuvola- ja kouluaikaisia pituuspainoluokituksia (Study I), 2) ryhmittelemällä lapset ala-asteen aikaisen ikäkohtaisen painoindeksin (BMI SDS) muutoksen ja siten ylipainon kehityksen perusteella luokkiin latent class mixed model -menetelmää (LCMM) käyttäen ja kuvaamalla näitä kehityskulkuja graafisesti (Study III) sekä 3) arvioimalla monitilamalleja (Markov multistate models) käyttäen lasten todennäköisyyttä siirtyä tilasta toiseen (normaalipaino – ylipaino – lihavuus) ala-asteen aikana (Study IV).

Perheeseen ja kouluun liittyvien taustatekijöiden yhteyttä lapsen ylipainoon tai lihavuuteen analysoitiin ensimmäisessä osatyössä. Taustatekijäiden yhteyttä todennäköisyyksiin siirtyä BMI SDS määritelmän mukaisen normaalipainon, ylipainon

ja lihavuuden välillä tutkittiin neljännessä osatyössä. Toisessa osatyössä tutkittiin ylipainon ja lihavuuden havaitsemisen ja lihavuuden hoidon toteutumista kouluterveydenhuollossa ja kolmannessa osatyössä toteutumisen yhteyttä havaittuihin painonkehityksen latentteihin luokkiin.

Tutkimuksen lapsilla lihavuus alkoi aikaisin, oli varsin pysyvää ja yleistyi ala-asteen aikana. Tyypillisiä ylipainon kehityskulkuja havaittiin tytöille viisi ja pojille neljä. Kymmenen vuoden iässä painon kehityskulkuja kuvaavat käyrät olivat lähellä toisiaan ylipainoalueella ja vain osa jatkoi tai palasi lihavuuden puolelle. Yhden vuoden aikana todennäköisintä oli, että ylipainon alueella olevat tytöt ja lihavuuden alueella olevat pojat pysyivät näissä samoissa painoluokissa.

Verrattuna ylipainoisiin lapsiin, lihavista lapsista suurempi osa oli ala-asteen aikana kokenut perhekriisejä, kiusaamista tai tarvinnut koulussa erityistä tukea oppimiseen (Study I). Tytöillä siirtyminen ylipainosta lihavuuteen oli yhteydessä yksinhuoltajuuteen tai vanhempien eroon, lihavuudessa pysyminen vieraskieliseen perheeseen. Pojilla siirtyminen ylipainosta lihavuuteen sekä ylipainoisena pysyminen liittyivät perheen kriiseihin ja koulukiusaamiseen.

Lakisääteiset terveystarkastukset terveydenhoitajille vuosittain toteutuivat hyvin, samoin kuin koululääkärille viidennellä luokalla. Huoltajat olivat ylimääräisillä ylipainoon liittyvillä vastaanotoilla mukana puolessa koululääkärin vastaanotoista ja 6 %:ssa terveydenhoitajan vastaanotoista (Study II). Ylipaino ja lihavuus tunnistettiin erinomaisesti, mutta lihavuusdiagnoosi asetettiin vain kolmannekselle lihavista lapsista. Hoito kohdistui lähinnä lapsiin, jotka jo olivat lihavia, vähemmän jatkuvasti lihoviin (Study III).

Lasten lihavuuden yksilöllisessä hoidossa sekä kouluterveydenhuollon prosessien suunnittelussa tulisi entistä paremmin huomioida tyypilliset ylipainon kehityskulut, perheeseen ja koulunkäyntiin liittyvät lihavuuden riskitekijät sekä lihavuudelta suojaavat tekijät. Näin hoitotoimet voisivat toteutua ja kouluterveydenhuollon käytössä olevat rajalliset voimavarat kohdentua terveyshyötyä enemmän tuottaen. Tulosten perusteella kouluterveydenhuollon tarkastusten toteutustapoja tulisi huolella arvioida. Laaja terveystarkastus, joka nykysin tehdään viidennellä luokalla, voisi joidenkin lasten lihavuuden ennaltaehkäisyn kannalta olla hyödyllisempää ajoittua aikaisemmin tai joustavammin. Työtapoihin, vanhempien kanssa tehtävään yhteistyöhön, diagnoosien kirjaamiseen ja hoitosuunnitelmien tekoon tulisi panostaa niin kehittämistyössä kuin tutkimuksessakin.

1 INTRODUCTION

The global prevalence of obesity of 5 to 19-year-old children multiplied by eight between 1975 and 2016 (NCD Risk Factor Collaboration 2017). By pooling population-based studies concerning weight development, researchers revealed an obesity prevalence of 5.6% for girls and 7.8% for boys. By 2016, the trend of mean BMI plateaued in north-western Europe and in some other high-income countries but continued to rise in east and south Asia (NCD Risk Factor Collaboration 2017).

In estimates of prevalence of childhood overweight and obesity, growth references and applied age ranges typically vary. Prevalence figures are therefore difficult to compare with each other. In Finland, the latest obesity prevalence for girls varies from 3% for 7 to 12-year-olds (Jääskeläinen et al. 2020) to 9% for 6 to 9-year-olds (Childhood Obesity Surveillance Initiative factsheet 2018). For boys, the corresponding percentages are 9% and 11%. Of 2 to 16-year-old girls, according to data from the Register of Primary Health Care Visits (Avohilmo), 17% were affected by overweight in 2019 and 20% of 13 to 16 years old girls (Jääskeläinen et al. 2020). The 2019 School Health Promotion Study in Finland, using self-reported measurements, concluded that 14.4% of 8th and 9th grade girls were affected by overweight (School Health Promotion study 2017/2019). For boys, the percentages in the above-mentioned studies were 27%, 29% and 19.5%, respectively.

Childhood obesity prevention belongs to all governmental institutions and functions of community and necessitates coordinated contributions for policy development (National Obesity Programme 2012-2018, Report of the Commission on Ending Childhood Obesity 2017). Primary health care constitutes the forefront for screening and treating childhood obesity. Yet, treatments call for supporting actors to enable multidisciplinary and individualised interventions embedded into the child's daily life (Richardson et al. 2013, Mead et al. 2017, Report of the Commission on Ending Childhood Obesity 2017, Obesity in children adolescents and adults: Current Care Guidelines 2020). In Finland child health clinics were implemented for every child in 1944 and are internationally acknowledged as a valuable structure for child health promotion. School health care, constituting a significant part of primary and preventive health care, establishes a natural continuum to this structure.

Models for organising school health care services vary significantly even among European countries (Baltag and Levi 2013). Of the 37 countries studied by Baltag and Levi, Finland, along with 11 countries, has a mixed school-based model in use. In this model, the services are based in schools and are organized by dedicated school health personnel and external primary care teams.

A Finnish decree from 2011 legislates school health care and defines the timing and content of health checks (Government decree 338/2011). Finnish school health care operates from school premises and covers all pupils. It aims to maintain the pupils' health and their ability to study by being preventive, family-oriented and multidisciplinary. However, evidence showing the benefit of the appointments is scarce (Nikander et al. 2018). To reach its goals and to reduce health inequality, school health care needs investments, appraisals and enhancements. Research around Finnish school health care is limited but further studies will no doubt support evidence-based decision making.

The school health care decree furthermore calls for identifying children with specialised support needs and for organizing interventions. Children with obesity, or a risk of developing it, need to be identified as they might need special support. School health care professionals meet children regularly and are in a position to organise multidisciplinary support to families. Yet, it remains uncertain if children with overweight and obesity receive ample intervention. Competences and habits of school nurses and physicians in prevention, screening and treatment of obesity are understudied. Knowledge on these, in their part, will guide towards evaluating benefits and to plan improvements in school health care -driven obesity mitigation.

Identifying children in risk of later health problems due to overweight or obesity is challenging (Ziauddeen et al. 2018). To direct available resources wisely, school health care professionals need knowledge on typical weight development patterns, as well as procedures for evaluating children's risk of obesity.

Events in early life are important predictors to weight development. High birth weight is associated with adulthood obesity (Skilton et al. 2014). Low birth weight, especially in preterm births, and early-life weight changes influence adversely later health and weight development (Barker 2004, Kajantie and Hovi 2014, Jornayvaz

et al. 2016). Additionally, some parental factors predict child weight development: socioeconomic status of parents, BMI of parents and mother's education (Juonala et al. 2020). These elements, although largely out of the reach of school health care professionals, are essential to consider when analysing obesity risk factors for primary school children. In order to prevent and treat obesity, school health care also needs to understand typical development of overweight and overweight- and obesity-related psychosocial factors, such as learning skills and experiences in being bullied. Health care professionals and other personnel in school environments are, fortunately, able to identify and influence these factors to some extent.

The National Obesity Program 2012 – 2018 of the Finnish Institute for Health and Welfare, "Wellbeing from healthy nutrition and physical activity", underlined the importance of childhood obesity prevention and treatment (National Obesity Programme 2012-2018). This aim of enhancing the ability of school health care to prevent and treat childhood obesity is in line with earlier strategic plans of the City of Helsinki and their latest Welfare Plan 2019-2021 (Welfare plan of the City of Helsinki 2019–2021).

This thesis searches for improvement areas within school health care processes on obesity prevention and treatment. The sub-studies explore overweight and obesity development among primary school children, associated psychosocial characteristics and school health professionals' ability to realise interventions (Figure 1:1).

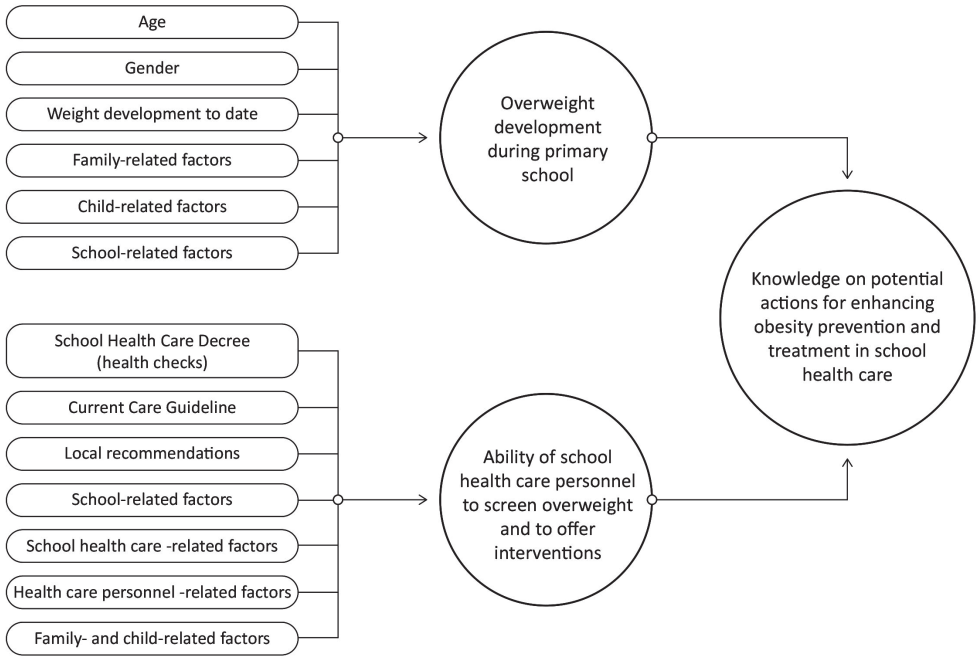


Figure 1:1 *Background and objective of the thesis*

2 REVIEW OF THE LITERATURE

This literature review aims to cover topics on childhood obesity development over primary school years and opportunities in school health care in prevention and treatment of childhood obesity. Even though lifestyle and habits ultimately effect weight development, many psychosocial background factors may support or prevent the actualisation of healthy nutrition and physical activity. This review concentrates on these background factors, especially on family- and school-related psychosocial characteristics. Distinct methods and results of obesity interventions are only covered on high level. The keywords “public care/public health care” and “childhood/child/children” and “overweight/obesity” as well as “prevention”, “screening” and “treatment”, were the basic elements in finding relevant literature. To obtain additional literature to cover family- and school related factors, search words as “bullying”, “family crises”, “SES”, “stress”, “studying difficulties”, “school achievements”, “learning abilities”, “cognition”, “family structure” and many of their synonyms from the acquired papers were used.

2.1 Childhood overweight and obesity

2.1.1 Definition of childhood overweight and obesity

Several national and international growth references defining overweight and obesity have been adopted. References differ by the characteristics of population data they are based on, methodological choices and cut-off points for underweight, overweight and obesity (Cole et al. 2000, de Onis et al. 2007, Saari et al. 2011, Cole and Lobstein 2012, Nilsen et al. 2016).

National growth references are usually constructed from local population data and are designed to follow the growth of individual children (Saari et al. 2011). They also consider ethnic differences and accurately observe country-level secular trends. National growth references are valuable in detecting conditions and diseases behind aberrations in growth trajectories and defining underweight, overweight, obesity and severe obesity, yet they are troublesome to use for international comparison (Butte et al. 2007).

Building an international growth reference challenges scientist and references have limitations particularly for assessing obesity and health risk evaluation (Butte et al. 2007, de Onis and Lobstein 2010). International Obesity Task force (IOTF) and World Health Organisation (WHO) references are widely applied and mainly designed for assessing the prevalence of thinness, overweight and obesity. The IOTF reference (Cole et al. 2000) includes BMI-for-age cut-offs for overweight and obesity, based on the extrapolation of BMI at the age of 18 and corresponding 25 and 30 kg/m^2 cut-offs for adults. The extended IOTF reference (Cole and Lobstein 2012) additionally offers cut-offs for thinness. IOTF charts lack percentile and z-score curves and have not been designed for monitoring BMI development of individual children (Himes 2009, de Onis and Lobstein 2010).

WHO growth references are developed for both clinical and public health applications and are designed for international use and comparisons between countries (de Onis et al. 2007). The WHO growth reference for 5 to 19-year-old children (WHO Growth reference data 2007) provides continuation for the WHO reference for under 5-year-olds (WHO Multicentre Growth Reference Study Group 2006). Unlike the latter, which was created from multicentre study data, the reference for school-age children was reconstructed from the 1977 curves of the US National Center for Health Statistics (NCHS) (de Onis et al. 2007). The NCHS curve approach was taken after two other databases, a multicentre study -based reference and a growth reference formed from existing historical data sets from multiple countries, were evaluated unsuitable. The reference for 5 to 19-year-old boys and girls transitions smoothly from the values for younger children. These WHO references include z-score and BMI-for-age percentile curves, 85th and 95th percentiles and +1SD and +2SD levels indicating the cut-offs for overweight and obesity.

Until recently, in clinical work in Finland, overweight and obesity were defined according to the national weight-for-height reference from 1980s (Sorva et al. 1984). This reference was based on growth measurements of Finnish children born between 1954 – 1972 and determined weight status as a percentage of the median weight of girls or boys of similar height. Weight-for-height references disregard the age of children as well as changes to their body composition with age. Overweight and obesity cut-off points abruptly shift at age 7. For under 7-year-olds, the cut-offs

for overweight and obesity are 110% and 120% of median weight, respectively, and from 7 years onward 120% and 140% (Obesity in children adolescents and adults: Current Care Guidelines 2020).

In 2011, Saari et al. published a novel age- and gender-specific BMI growth reference for Finnish children (Saari et al. 2011). They utilised growth measurements of over 70 000 children born in Espoo, Finland, between 1983 – 2009 and set gender-specific BMI SDS cut-offs for overweight and obesity. Since October 2011, the Finnish Institute for Health and Welfare (Kasvunseurannan asiantuntijaryhmän raportti 2011) as well as the Current Care guidelines (Obesity in children adolescents and adults: Current Care Guidelines 2020) have advised municipalities in Finland to apply the novel BMI reference in clinical work. Integration to electronic health records took some time, and finally Helsinki implemented the new growth reference in 2016.

The IOTF reference (Cole et al. 2000), the extended IOTF reference (Cole and Lobstein 2012) and WHO growth references (WHO Growth reference data 2007) are widely used in scientific studies, also in Finland.

2.1.2 Prevalence of childhood overweight and obesity

Heterogenic growth references impede international comparisons and produce variation in the observed prevalence of overweight and obesity, as demonstrated by Mäki et al. in Finnish population (Mäki et al. 2012, Mäki et al. 2017a). In order to determine the prevalence of childhood overweight and obesity and to compare prevalence between countries, consensus on the recommended international growth reference is needed (Butte et al. 2007). In combination with accessible representative growth measurement data, a common reference could also provide meaningful longitudinal information. Such growth data have been available from a limited, yet growing, number of countries (Wijnhoven et al. 2014, Nilsen et al. 2016, Mäki et al. 2017a). The need for population-level data, along with increasing encouragement for individual weight status assessment of children, have led to new national monitoring programs (Davidson et al. 2018). The European Childhood Obesity Surveillance Initiative (COSI 2020), established in 2006, applies WHO growth references to national data, allowing reliable inter-European comparisons

of the prevalence of overweight and obesity among primary school aged children (Wijnhoven et al. 2014). Finland has been a part of the initiative since round 4, covering 2015 – 2017, and the comparison results to other European countries are now available (Childhood Obesity Surveillance Initiative factsheet 2018).

2.1.2.1 Prevalence of childhood overweight and obesity globally

Childhood overweight and obesity, as in adulthood, has increased globally during the last decades (Ng et al. 2014, NCD Risk Factor Collaboration 2017). From 1980 to 2013 the prevalence of overweight for men increased from 28.8% to 36.9% and for women from 29.8% to 38.0% (Ng et al. 2014). Obesity of 5 to 19-year-olds increased from 0.7% to 5.6% in girls and from 0.9 to 7.8% in boys between 1975 and 2016 (NCD Risk Factor Collaboration 2017). During the same time period, the mean BMI of 5 to 19-year-olds has climbed, although there are substantial regional differences. After 2000, the mean BMI has plateaued in north-western Europe and some other high-income countries yet increased in southern and eastern Asia.

In 2016, the obesity prevalence of 5-19-year-old children varied from 30% in Nauru and Cook Islands through around 20% in the United States, Caribbean area and many countries in the Middle East, northern Africa, Polynesia and Micronesia, to 5 to 10% in western Europe and around 2% in India, Vietnam and many African countries (NCD Risk Factor Collaboration 2017).

According to the earlier mentioned COSI initiative, prevalence and 2007-2017 trends of overweight and obesity of 6-9-year-olds vary significantly among European countries and between genders (Childhood Obesity Surveillance Initiative factsheet 2018). The first comparison of Finland to other European countries from years 2015-2017 put Finland in the middle range of prevalence.

2.1.2.2 Prevalence of childhood overweight and obesity in Finland

In Finland, all children attend health checks in child welfare clinics and in school health care and therefore growth measurements are potentially available. Yet, a national structure for monitoring was non-existent until from 2011 all municipalities were obligated to transfer data to the Register of Primary Health Care Visits

(Avohilmo) maintained by the Finnish Institute for Health and Welfare (THL) (Health Care Act 1326/2010, Government decree 338/2011). EHRs in primary health care around Finland differ and the incompatibility of some of them with Avohilmo hinders the sharing of growth measurement data. The percentage of the municipalities being able to deliver growth measurements of at least 65% of the children living in their area has increased between 2014-2015 and 2016-2017 (Mäki et al. 2018). Finland is now beginning to acquire comprehensive real-time data of the prevalence of childhood overweight and obesity. Data from 2018 were already published in spring 2019 and results from 2019 in September 2020 (Jääskeläinen et al. 2020).

Earlier, the prevalence of childhood overweight in Finland was estimated from local cohort studies and from studies using self-reported height and weight measurements, such as the national School Health Promotion Study, the Adolescent Health and Lifestyle Survey and the Health Behaviour in School-aged Children (HBSC) of WHO. Cross-sectional and longitudinal retrospective cohort studies have already shown that the prevalence of overweight and obesity has multiplied among Finnish children and adolescents since 1974 (Porkka et al. 1997, Kautiainen et al. 2002, Vuorela et al. 2009, Vuorela et al. 2011). The increases were most substantial among teenage boys and prevalence increased with age. According to a retrospective cross-sectional study in greater Tampere area, the prevalence of overweight and obesity of 12-year-olds almost doubled between 1986 and 2006, but for 5-year-olds it was stable by IOTF criteria (Vuorela et al. 2009). For 12-year-old boys, overweight increased from 12.8% to 23.6% and for girls from 12.9 to 19.1%.

Disclosed prevalence numbers of childhood overweight and obesity in Finland vary as definitions, population, age range and data collection differ. According to the COSI initiative and the WHO criteria, of 6-9-year old children in Finland in 2015-2017, 28% of boys and 27% of girls were overweight and 11% and 9% obese, respectively (Childhood Obesity Surveillance Initiative factsheet 2018). Avohilmo data from Finland in 2016-2017 indicate, when using the definitions made by the Finnish national ISO-BMI growth reference, that overweight and obesity are most prevalent among teenage boys (Mäki et al. 2018). Of girls aged 2-16, 16% were affected by overweight and 3% by obesity. For boys, the numbers were 26% and 7%,

respectively. From 2019 onwards the percentages are slightly higher; for girls 17% and 4% and for boys 27% and 8%, respectively (Jääskeläinen et al. 2020).

The prevalence of overweight in Finland is higher in studies using cross-sectional methods or Avohilmo register data than in studies based on self-reporting. The School Health Promotion Study in Finland uses self-reported height and weight measurements from adolescences and classifies overweight and obesity by IOTF references. The study started in 1996 among 8th and 9th graders (14 to 15-year-olds) and, since 2017, 4th and 5th graders (10 to 11-year-olds) have answered the questionnaires, yet weight and height are not asked from primary school children (School Health Promotion study 2017/2019). According to the study, overweight of 8th and 9th grade girls has slowly increased from 11.4% (2006-2007) to 14.4% (2019). For boys, it has stabilized near 20%, the latest count in 2019 being 19.5%.

Some Finnish studies have used two of the three above-mentioned growth references (IOTF, weight-for-height, BMI-for-age) to compare overweight and obesity prevalence. Compared with the IOTF reference, weight-for-height classifies a larger part of Finnish five-year-old children as overweight (Mäki et al. 2012). On the contrary, more first and fifth graders were defined as overweight by IOTF than by the weight-for-height reference. Of first graders, especially younger children (under 7-year-olds) were defined more frequently as overweight by to the weight-for-height reference. When utilizing Avohilmo register data, obesity among 7-12-year-old girls was less common by the Finnish BMI-for-age than by the IOTF reference (Mäki et al. 2017a). For boys, the result was reversed, obesity being more common using the Finnish BMI-for-age reference, especially among younger boys.

Childhood overweight and obesity is less common in large cities and urban areas. This is true for Finland and other developed countries (Cherry et al. 2007, Vuorela et al. 2009, Mäki et al. 2017a, Erdei et al. 2018, Mäki et al. 2018) although community socioeconomic deprivation seems to have an effect over the rural-urban classification (Poulsen et al. 2019). Of 7-12-year-old girls in Helsinki in 2018, 15% (18% in Finland) and of boys 24% (28% in Finland) were overweight based on Avohilmo data (Lasten ja nuorten ylipaino ja lihavuus 2019). Differences between urban and rural areas are also visible in the School Health Promotion Study. In 2019

in Helsinki, 11.8% of 8th and 9th grade girls and 14.7% of boys were overweight, compared with 14.4 % and 19.5% in Finland as a whole, respectively (School Health Promotion study 2017/2019). The proportion of girls with overweight in Helsinki has slowly increased from 8.6% (2006-2007) to 11.8% (2019), yet, in boys in the same timeframe, overweight has slowly decreased from 16.6% to 14.7%.

2.1.3 Development of overweight and obesity during childhood and adolescence

Childhood obesity often begins to develop early on (Cunningham et al. 2014, Woo Baidal et al. 2016). Adolescents affected by overweight start to gain excessive weight already at 2 to 6 years of age, girls earlier than boys (Lagström et al. 2008, Geserick et al. 2018). Accelerating weight development during the first three years after birth or overweight at 2 years of age predict overweight later in childhood; information on other risk factors increases the predictive value of the child's weight data (Giles et al. 2015, Ziauddeen et al. 2018, Ziauddeen et al. 2020).

Studies on predictive models have focused on using data from maternal antenatal, birth and early-life (Ziauddeen et al. 2020); also, from maternal weight and education (Juonala et al. 2020). Additionally, indoor smoke exposure has been shown to predict later overweight (Welten et al. 2020). Factors associated with obesity resolution remain, to date, less investigated than obesity development, although both are important when aiming to allocate resources meaningfully; interventions should be targeted at those most probably developing obesity and to those presumably without a natural ability to resolve obesity (Juonala et al. 2020).

Over childhood, overweight and obesity become more common with age and their prevalence increases especially during the first school years (Vuorela et al. 2009, von Kries et al. 2012, Wheaton et al. 2015, Moreira et al. 2019). For adolescents, this can be explained in part by decreased levels of physical activity (Kimm et al. 2005). Weight development during primary school years is apparently related to the body image of a child, and the association seems to differ according to gender and baseline weight status (Duchin et al. 2015).

The incidence of obesity and remission from it both constitute important study fields for deepening our understanding of mechanisms behind changes in prevalence. The mounting prevalence of overweight from preschool age to school age is certainly related to the increased incidence of overweight, yet the reduced remission rate is a major contributor (von Kries et al. 2012, Wheaton et al. 2015, Moreira et al. 2019). Increased maintenance of excess body fat is a cause to the latter (von Kries et al. 2013).

Weight trajectories constitute a manner to investigate weight development and resolution during childhood. Advanced statistical techniques of the 21st century have been used to illustrate distinct trajectories of BMI development of children. Latent class growth analysis, one of these techniques, can be utilised to find groups of people with similar BMI development. In September 2020, PubMed found 133 references by the following keywords: (child or children or childhood) and (overweight or obesity) and (primary school or school-age) and (trajectory). Table 2:1 includes relevant papers from these and presents them and other cohort studies that have utilised Latent class mixed model or similar advanced growth analysis techniques on BMI development over primary school years. Studies have found 2 to 6, most commonly 3 or 4, latent classes of BMI development. The methods, growth references, number of growth measurements used in these studies varies, as well as the gender set-up (girls and boys separately or together) and the age range of children.

Examining probabilities to transition from a weight category to another also offers a method to study bidirectional changes (Table 2:2). Those with obesity or with normal weight at the age of 3 years were relatively unlikely to move into the overweight category by the age of 15 (Tran et al. 2016). A higher level of education of a child's mother was associated with a lower probability of transitioning from normal weight to overweight or overweight to obesity (Moreira et al. 2019).

Table 2:1 *Cohort studies on BMI trajectories (BMI/BMI percentiles/BMI z-scores) over primary school years with statistical approach of group-based mixture modelling*

Author, year	Place, time and type of study	Statistical approach	Sample size	BMI measure and growth reference	Age window of trajectories. number of growth assessments	Number and names of trajectories	Associations of studied factors with trajectories	Identified predictors of overweight development
Li et al. 2007	United States; 1986-2000. Prospective	Growth mixture modelling	1739	Overweight / non-overweight, weighted probability of overweight. BMI percentiles (CDC)	From under 2 to 12 years of age. 3 (at least)	3: *Never overweight, Early-onset overweight, Late-onset overweight*	N/A	Ethnicity, gender, birth weight, maternal BMI and smoking associated with increased risk of overweight development; breastfeeding with decreased risk
Hejazi et al. 2009	Canada; 1996/1997-2002/2003. Prospective	Group-based mixture modelling	972	BMI (IOTF)	24 months - 107 months. 4 (biennial)	Sex-specific trajectories. Girls 4: *Stable normal BMI, Early declining BMI, Late declining BMI, Accelerating rise to obesity.* Boys 3: *Stable normal BMI, Transient high BMI, J-curve rise to obesity*	N/A	N/A
Carter et al. 2012	Canada, Québec; 1998. Prospective	Group-based trajectory modelling	1566	BMI z-score (CDC)	4-10 years of age. 5	4: *Low-increasing, Low-medium, accelerating, Medium-high, increasing, High-stable*	N/A	Living area, obesity status of the mother, smoking during pregnancy, and overeating behaviours related to trajectories
Haga et al. 2012	Japan; 1991-1998. Prospective	Group-based semipara-metric mixture modelling	1644	BMI z-scores (WHO)	0-12 years of age. 11	Sex-specific trajectories. Boys 5 and girls 6: *Stable thin, Stable average, Stable high average, Progressive overweight, Progressive obesity*. Girls additionally: *Progressive average*	N/A	Maternal weight, smoking and skipping breakfast during pregnancy associated with the progressive obesity pattern (stronger for boys)

Jansen et al. 2013	Australia; 2004-2010. prospective	Latent class analysis	4949	BMI/BMI z-scores (IOTF)	From 4-5 to 10-11 years of age. 4 (biennial)	BMI: 4: *persistent overweight, late overweight, resolving overweight, stable normal weight*; BMI z-scores: 5*: High rising, moderately rising, stable normal weight, stable low, stable very low*		Children in low SES families had a highest risk of persistent or late-onset overweight. Birth weight or parental overweight explained this risk only partly
Magee et al. 2013	Australia; 2004-2010. Prospective	Growth mixture modelling	1079	BMI	4-11 years of age. 4	3: H*ealthy weight, Early onset obesity, Later onset obesity*	N/A	Longitudinal inverse associations between sleep duration and BMI in the Early Onset trajectory
Batscheider et al. 2014	Germany; 1995-1998 and 1997-1999. Prospective	Latent growth mixture modelling	3635	BMI z-scores (WHO)	0-10 years of age. 6	3: *Normative BMIZ growth, Rapid BMIZ growth up to age 2 years only, Persistent rapid BMIZ growth up to age 5 years*	Direct medical costs at 10 years of age were doubled for children with persistent rapid BMIZ growth compared with the other children	N/A
Lin et al. 2014	Taiwan; 2001-2006. Prospective	Group-based trajectory models	1609	BMI	7-12 years of age. 6	Sex-specific trajectories. Girls 4*: persistently slightly underweight, persistently normal weight, persistently overweight, persistently obese*; Boys 4*: normal or slightly underweight, persistently normal weight, overweight becoming obese, persistently obese*	Girls: BMI trajectories associated with television viewing or computer use, family interactions, peer interactions, and overweight parents. Boys: with after-school exercise, academic performance, family interactions, overweight parents, and father's education level	N/A
Nummi et al. 2014	Finland; 1974, 1981, 1991, 1995 Retro-spective	Latent class growth analysis	4223	BMI	0-15 years of age. 8	Sex-specific trajectories. Girls and boys 4: *Low birth BMI growth track, lower normal growth track, upper normal growth track, overweight growth track*	N/A	Earlier adiposity rebound associated with the *Overweight growth track*

Brault et al. 2015	Canada; from 2010-2013. Prospective	Latent class growth analysis	461	BMI	Three-year follow-up between 8 and 14 years of age. 4	Sex-specific trajectories. Girls 4: *Normal-low quadratic, Decreasing-normal, Steady-overweight, Persistent-obese.* Boys 4: *Decreasing thin, Normal-low decreasing, Normal-high decreasing, Steady-overweight*	N/A	Sociocultural factors were associated with the trajectories. Body satisfaction was related to BMI trajectories. Dissatisfaction was higher among children in overweight or obese trajectories than in the other trajectories
von Bonsdorff et al. 2015	Finland; 1934-1944, Retro-spective	Latent class growth mixture modeling	4943	BMI	0-11 years of age. 34	Sex-specific trajectories. Girls 3: *Increasing BMI, Average BMI, and low-to-high BMI.* Boys 3: *Increasing, Average, Average-to-low*	Early BMI development associated with all-cause mortality among women and cancer mortality among women and men (age at outcome 56-67)	Boys: Lower gestational age associated with *Increasing* trajectory
Chen et al. 2016a	United States, Texas; 2005 onward. Prospective	Group-based trajectory model	1651	BMI z-score (CDC)	From the start of kindergarten to the beginning of 5th grade. 11(biannual)	5: *Persistently Non-Overweight / Obese, Late-onset Overweight / Obese, Early-onset Overweight / Obese, Becoming Healthy, Chronically Overweight / Obese*	N/A	Gender (Boy) and ethnicity (Hispanic, non-Hispanic black) predictors for chronic overweight or obesity
Kelly et al. 2016	UK; 2000-2013. Prospective	Latent class growth analysis	16 936	BMI	3-11 years of age. 4	4: stable, decreasing, moderate increasing, high increasing	Children in increasing groups had worse scores in psychosocial well-being at age 11	Predictors for increasing groups were smoking in pregnancy, maternal BMI, skipping breakfast, non-regular bedtime
Koning et al. 2016	Netherlands 2006-2012. Prospective	Latent class growth mixture modelling	613	BMI SDS (National Growth Study reference)	4-12 years of age. 3	2: *Decreasing BMI SDS trajectory, Increasing BMI SDS trajectory*	N/A	Latent class associated with different health related behaviour and with mother being overweight
Munthali et al. 2016	South Africa, Soweto. Prospective	Latent class growth mixture modelling	1824	BMI	5-18 years of age. 7 on average	Sex-specific trajectories. Girls 4: *Normal Weight, Late Onset Overweight, Early Onset Obese to Overweight, Early Onset Obese to Morbidity Obese.* Boys 3: *Normal Weight, Early Onset Overweight to Normal Weight, Early Onset Overweight to Obese*	Early onset adiposity trajectories associated with elevated blood pressure in late adolescence (17-18 years of age) in boys and girls	N/A

Peneau et al. 2017	France, 2009. Retro-spective	Latent class growth mixture modelling	1188	BMI (IOTF and French reference)	0-10 years of age. 9	5: *Stable-25th, Stable-50th, Stable-75th, Ascending-75th, Ascending-obesity*	Cardiometabolic risk-factors in adulthood (at 20-69 years of age). Trajectories were associated with adult BMI and waist circumference	Trajectories associated with gestational age and birth weight
Lanza et al. 2018	USA; 2009-2014. Prospective	Growth mixture modelling	5991	BMI percentiles (CDC)	From 6th school grade to 8th grade. 4	5: *Low, Moderate, High, Decreasing, Increasing*	Children in the moderate trajectory had less experiences on being bullied than in other trajectories; children in the *High* trajectory reported the highest levels of victimization	N/A
Lycett et al. 2020	Australia; 2004-2014. Prospective	Group-based growth curve trajectory modelling	3900 / 1811	BMI z-score (CDC)	2-3 to 10-11 years of age. 5 (biennial)	5: *Low, Low to high, Always very high, Healthy, Always high*	Cardiometabolic risk factors (metabolic syndrome risk scores, carotid-femoral pulse wave velocity and carotid intima-media thickness) at the age of 11-12 associated with overweight and obesity	N/A
Pineros-Leano 2020	USA; from 1998. Prospective	Group-based trajectory modelling	3500	BMI z-scores (WHO/CDC)	0-10 years of age. 5	3: *stable, mid-rising, high-rising*	Maternal depression not related to obesity development of children	Maternal pre-pregnancy BMI, number of biological children in the house, Latino ethnicity predicted rising trajectories

BMI, body mass index; CDC, The Centers for Disease Control and Prevention (CDC) 2000 Growth Charts; IOTF, International Obesity Task Force; WHO, World Health Organization

Table 2:2 *Prospective cohort studies that have utilised multistate models on weight category transitions over primary school years*

Author, year	Place, time and study setting	Cohort	Sample size	Follow-up	Timing / number of weight category assessments	Weight category assessed by	Statistical methods	Covariates	Outcome measures	Results
Chen et al. 2016b	United States, Texas; 2005 onwards	Elementary school children. Kindergarten - fifth grade, between 5 to 12 years of age. Mean age in the beginning 5.7	1494	5 years	11, biannual	A standardized BMI score (zBMI) and percentile (CDC)	First-order three-state Markov chain modelling	Gender, race/ethnicity, school level SES, measurement time (fall / spring)	Transition probabilities between healthy weight, overweight and obesity	Children most likely stayed in the same category as at the previous assessment. Gradual and constant shift to overweight and obesity. The probability of becoming overweight or obese was greater during summer months. Gender, ethnicity and SES related to transition probabilities
Tran et al. 2016	United States, Colorado, 2007 - 2013	Public school children; 3 to 15-year-olds	65 672	6 years	Mean: 2.7 / child	BMI (CDC)	Multistate life table methods, 4 possible transitions	Age, sex, ethnicity	Transition rates, years expected to stay at each category by ethnicity and sex	Children with normal weight or obesity at the age of 3 most probably stayed at that category for the next 13 years. Children with overweight were expected to move either to normal weight or obesity and spent most of the 13 years at different weight category
Moreira et al. 2019	Portugal, 2005 - 2017	Children from the Generation XXI Birth Cohort Study; between 4 and 10 years of age	4887	From 4 years of age to the age of 7 or 10	2 or 3	Standard deviation of BMI z-scores (WHO)	Markov 4-state model; 6 possible transitions	Maternal age and education, type of delivery, sex and birth weight	Transition rates	The most likely transitions: from underweight to normal weight and from normal weight to overweight. Children with overweigh had similar rates for transitioning to the two adjacent categories. Sex and maternal education related to transitions

Wu et al. 2019	China, 2004 - 2009	Elementary school children. Mean age at baseline (first grade) 7.08.	928	Average 5.98	Annually	According to the gender- and age-specific cut-off points developed by the Chinese Working Group on Obesity for Children (Group of China Obesity Task Force, 2004)	Markov 3-state model; 4 possible transitions	Gender, school grade, initial BMI, VCI, AHI, AWI	Transition intensities	Children with healthy weight and obesity tend to stay in these states. Children with overweight more likely moved to the other two states. The mean sojourn time in obesity: 5.15, in overweight: 2 years. Children in lower grades, those with a lower VCI, a higher initial BMI, a higher AWI, and boys were at increased risk of overweight or obesity and had decreased probability of regression. Children with overweight were less resistant to recovery than those with obesity

AHI (annual height increment); AWI (annual weight increment); CDC, Centers for Disease Control and Prevention (CDC) 2000 Growth Charts; SES, socioeconomic status; VCI (vital capacity index); WHO, World Health Organization growth references

2.1.4 The continuity of childhood overweight and obesity to adulthood and its metabolic consequences

Childhood BMI strongly predicts BMI later in childhood, adolescence and adulthood (Fuentes et al. 2003, Singh et al. 2008, Juonala et al. 2011b, Simmonds et al. 2016, Juonala et al. 2020). High birth weight by itself is already related to long-term overweight risk (Schellong et al. 2012, Sparano et al. 2013, Skilton et al. 2014). Obesity at the age of 7 predicts obesity at the age of 15 (Fuentes et al. 2003) and BMI at 6 years of age indicates BMI in early adulthood (Magarey et al. 2003). The predictive value of BMI in childhood increases with age (Singh et al. 2008, Simmonds et al. 2016, Juonala et al. 2020). Therefore, BMI, especially at adolescence, predicts BMI in later life (Juhola et al. 2011) and obesity at adolescence potentially continues into adulthood (Simmonds et al. 2016).

Around a half of the children with obesity will continue with obesity in adolescence and even 80% of adolescents with obesity will be affected by obesity in adulthood (Simmonds et al. 2016). Corresponding percentages in individual studies vary from 24% to 90% (Singh et al. 2008). Obesity at childhood, especially after 12 years of age, predicts obesity in adulthood (Juhola et al. 2011). The relation between childhood obesity and obesity in early adulthood is even firmer when both parents are overweight (Magarey et al. 2003). On the contrary, of 4 to 5-year-old children with overweight or obesity, approximately 40% were in normal weight area at age of 10-11 years (Wheaton et al. 2015).

In addition to increasing age, the predictive value of childhood overweight also strengthens with increasing BMI (Singh et al. 2008, Juonala et al. 2020). Children with overweight are twice as prone to having overweight as adults than their normal weight peers (Singh et al. 2008), but children and adolescents with obesity have a five-fold likelihood of becoming obese in adulthood (Simmonds et al. 2016). Several studies have investigated distinct weight trajectories during childhood and as well their association with weight status in later life (Table 2:1). Both the stable high and the rapid weight gain trajectories have been associated with higher adult BMI (Peneau et al. 2017, Mattsson et al. 2019).

Regardless of the persistency of overweight and obesity, most adults with obesity (70% to 80%) have been in normal-weight area during childhood (Juhola et al. 2011, Simmonds et al. 2016). Consequently, it has even been speculated whether obesity and overweight prevention in childhood is needed or effective when targeting to counteract the obesity epidemic (Simmonds et al. 2016). Still, study on BMI trajectories from childhood to late adulthood showed that adolescents with normal weight who developed obesity in adulthood had higher BMI from 6 years onward compared with those who were not obese in youth nor in adulthood (Buscot et al. 2018a). Additionally, their BMI increased faster from youth until the age around 30.

Childhood obesity can have adverse short- or long-term psychological, cardiovascular or other health-related effects, or it may have social or economic consequences (Reilly et al. 2003). It is noteworthy that childhood obesity is not only related to health issues in adulthood but also already in childhood (Park et al. 2012, Kelly et al. 2013). In childhood, psychosocial effects play a major role and then, in adulthood, metabolic outcomes enter the scene. However, cardiometabolic effects are identifiable already in childhood (Järvisalo et al. 2001). Furthermore, early-childhood obesity is associated with preclinic cardiometabolic risk factors for children ending primary school (Lycett et al. 2020). This supports starting obesity prevention as early as possible.

Childhood overweight and obesity lead to an increased risk of coronary heart disease in adulthood (Baker et al. 2007, Juonala et al. 2010). Cardiometabolic risk factors, such as high serum LDL-cholesterol and low HDL-cholesterol levels, as well as high blood pressure, potentially continue from childhood to adulthood (Juhola et al. 2011). Also, childhood weight trajectories have been related with cardiometabolic risk factors, such as carotid intima-media thickness in childhood (Lycett et al. 2020), blood pressure in late adolescence (Munthali et al. 2016) and BMI and waist circumference in adulthood (Peneau et al. 2017).

Whether childhood obesity is associated with cardiovascular outcomes in adulthood independently from adulthood obesity has been an area of interest (Park et al. 2012). In addition to obesity, excessive weight gain during childhood seems to

be associated with cardiovascular risk factors and coronary heart disease in adulthood (Bjerregaard et al. 2020a). Nevertheless, studies show that the adverse consequences of childhood obesity to cardiometabolic outcomes in adulthood may reduce if children with obesity move to normal-weight area before adulthood (Juonala et al. 2011b, Bjerregaard et al. 2020b).

Childhood obesity also increases the risk for premature death (Franks et al. 2010). Increased cancer and all-cause mortality were noticed for women with rising BMI trajectories during childhood (von Bonsdorff et al. 2015).

2.2 Family- and school-related factors associated with childhood overweight and obesity

2.2.1 Family-related factors associated with childhood overweight and obesity

Parental BMI, especially the mother's (Brisbois et al. 2012, Robinson et al. 2015, Juonala et al. 2020), seems to be a significant predictor of childhood overweight and is even more so when both parents are overweight (Parikka et al. 2015, Wang et al. 2017). Still, other parent- and family related factors also increase the risk, such as high socioeconomic status (SES) for developing countries and, vice versa, low SES for developed countries (Juonala et al. 2011a, Brisbois et al. 2012, Wang and Lim 2012, Wheaton et al. 2015) where the socioeconomic inequality in weight seems to continue widening (Chung et al. 2016).

Numerous studies have investigated weight trajectories and their associations with child- and parental-related characteristics, such as gender and ethnicity (Li et al. 2007, Chen et al. 2016a, Pineros-Leano 2020), early childhood nutrition (Garden et al. 2012), local environment and early life factors (Carter et al. 2012), socio-economic status (Jansen et al. 2013, Chen et al. 2016a, Koning et al. 2016), maternal factors during pregnancy (Haga et al. 2012, Hakanen et al. 2016, Kelly et al. 2016) and maternal obesity (Li et al. 2007, Haga et al. 2012, Lin et al. 2014, Koning et al. 2016). Also, factors relating to lifestyle during primary school years have been related to overweight trajectories (Lin et al. 2014, Kelly et al. 2016). Results from

these longitudinal studies strengthen the knowledge on the impact of family and maternal factors on childhood weight development (Table 2:1).

The education level of parents has been used as an indicator of family SES. In a Finnish study, low parental education was directly associated to childhood overweight and also indirectly through parental BMI (Parikka et al. 2015). Also, in the Finnish School Health Promotion Study the low education of the mother, as well as low SES and financial problems of the family, were related to overweight of school-age children (Mäki et al. 2019b). The knowledge on mothers' BMI and education therefore offers a potentially useful combination as a predictor (Juonala et al. 2020).

Family stressors may originate from multiple issues in life, and are, overall, associated with the weight status of a child (Garasky et al. 2009, Parks et al. 2012, Shankardass et al. 2014). These stressors may affect differently depending on the gender and age of a child. For example, overweight and obesity were common among young children experiencing a lack of emotional support due to family stressors, whereas the same applied to older children when their families were experiencing health problems or financial challenges (Garasky et al. 2009). Multiple stressors intensify the risk for overweight and obesity (Parks et al. 2012). Psychosocial stress additionally deteriorates results of obesity interventions (Phan et al. 2018).

Low SES has been proposed as a major cause for family dysfunction and parental and offspring stress or emotional turmoil (Hemmingsson 2018). This distress, in turn, has been suggested to be a major mediator between low SES and childhood obesity (Hemmingsson 2018, Miller and Lumeng 2018). Two potential pathways from stress to childhood obesity are 1) biological stress systems in early-life (Miller and Lumeng 2018) and 2) stress induced self-medication with food, especially high-calorie food (Hemmingsson 2018). Also, parent-perceived stress was associated with children's consumption of fast foods (Parks et al. 2012). Low SES may induce childhood overweight through parenting behaviours (Russell et al. 2016). For example, low parental educational is associated with a higher risk of primary school age children skipping breakfast and not eating the recommended 4-6 meals a day (Parikka et al. 2018). Childhood low SES can also lead to an unhealthier lifestyle at adulthood (Puolakka et al. 2018). As the diverse pathways connecting low SES,

parental behaviour, stress and weight status of children are not fully understood, the field could do with further study (Russell et al. 2016, Miller and Lumeng 2018).

In obesity prevention and treatment, family stressors must be considered, causes behind excessive eating explored and a multidiscipline approach implemented (Hemmingsson 2018). Traditional nutrition and physical activity -focused interventions, which fail to affect the causes behind obesity development, may turn out to be useful only for high SES families. This may boost health-related inequity (Hemmingsson 2018, Chung et al. 2016). Fortunately, the phenomenon has been noticed among social work professionals (Lawrence et al. 2010) and addressed in Current Care Guidelines (Obesity in children adolescents and adults: Current Care Guidelines 2020).

In Finland, family structures are now more diverse and nuclear families with children have become rarer since 1950 (Statistics Finland 2018). Studies emphasize the significance of family structure on childhood obesity. Children living in single-parent families face a greater risk of obesity (Duriancik and Goff 2019, Hankey and Miyazaki 2019). In a Finnish study, 11-16-year-old girls living in nuclear families had a decreased risk of being affected by overweight (Parikka et al. 2015). For younger children the results have been similar; 3 to 5-year-old children living in single-parent families were in unhealthier weight trajectories than those living with both parents (Schmeer 2012). Eating habits also differ; children living in single-parent families are less likely to eat breakfast or the recommended 4-6 meals a day than their peers in nuclear families (Parikka et al. 2018). The previously mentioned SES factors and parental stress are possible mediators and therefore the unique challenges of single-parent families earn further analysis (Duriancik and Goff 2019).

2.2.2 Bullying

2.2.2.1 Different forms of bullying

A child may unfortunately become a victim or a perpetrator of bullying. Direct or undirect bullying manifests itself as physical, verbal or relational bullying or as damage to property (Gladden et al. 2014). Excluding a person from her peer group offers an example of direct bullying and spreading rumours is indirect relational

bullying. Children with obesity are often victimized by direct verbal bullying, such as being called names (Wang et al. 2010). Contexts for bullying are numerous, such as school, hobbies, neighbourhood, and internet. Studies investigating the relation of body weight and bullying have classified bullying as either *overt bullying* (physical or verbal bullying) or *relational bullying* (exclusion in social situations) (Griffiths et al. 2006).

2.2.2.2 Prevalence of bullying

The observed prevalence of bullying varies substantially according to study methods. The worldwide mean for victimisation in adolescence reaches 36% (Modecki et al. 2014). In an Irish study, 40% of nine-year-olds were victimised by bullying during the previous year (Reulbach et al. 2013). Children might underreport bullying or define bullying differently than adults. In the United States, mothers of sixth graders reported more bullying of their children than their children themselves (45% vs. 25%) (Lumeng et al. 2010).

In Finland, a third of the parents of first graders reported that their child had been bullied in the previous few months (Mäki et al. 2010). The percentages for fifth graders were lower than for 1st graders and the lowest percentages were found for fifth grade girls (10%). In the latest School Health Promotion Studies in Finland from 2017 and 2019, 4th and 5th graders were asked about bullying. In Helsinki, 8% of them reported having been victims of bullying at school at least once a week during the school year (School Health Promotion study 2017/2019), while 64% had entirely avoided bullying. Of the 4th and 5th graders, 14% reported having been bullied either in their free time or at school due to their weight, height or body appearance.

2.2.2.3 Relation of bullying to overweight and obesity, mediators

Experiences in being bullied remain more common among children with obesity and overweight, both in pre-adolescence and adolescence, than among their normal-weight peers (Brixval et al. 2012, Reulbach et al. 2013, van Geel et al. 2014, Lanza et al. 2018). In some studies, solely obesity has been associated with victimisation by bullying (Griffiths et al. 2006, Lumeng et al. 2010). A meta-analysis

reported no differences between gender in the association between victimisation by bullying and weight status (van Geel et al. 2014). However, in low- and middle-income countries only adolescent girls with overweight or obesity had higher odds for victimisation than their normal-weight peers (Koyanagi et al. 2020). Being bullied by making fun of someone's physical appearance, instead, was associated with weight for both genders.

The relation between overweight and being bullied is presumably bidirectional. Obesity or overweight might either induce or follow bullying. Studies on primary school children lean towards obesity and overweight being the cause. Being bullied in third grade was unrelated to weight gain over the next two years (Lumeng et al. 2010), and obesity at 7.5 years of age predicted victimisation by bullying a year later (Griffiths et al. 2006).

A child's body image constitutes a mediator between weight status and bullying (Brixval et al. 2012, Reulbach et al. 2013). Poor body image alone, independent from weight status, associates with victimisation and perpetration by bullying (Reulbach et al. 2013). Even though researchers tend to perceive the relation between obesity and self-esteem as a unidimensional challenge, it constitutes a multidimensional and dynamic relationship (Hill 2017, Brault et al. 2015). According to Hill, among reasons for obesity, the lack of self-esteem presumably does play a small role, but other personal differences explain the greater part. Yet, the negative influences of obesity on self-esteem accumulate over time and higher BMI.

Among girls, the highest odds ratio (OR) of being bullied was for those feeling they were much too fat, yet for boys it was for those feeling much too thin (Brixval et al. 2012). Cross-sectional studies are unable to prove the causality. Nonetheless, these findings support the interpretation that low self-esteem precedes victimisation by bullying (Reulbach et al. 2013). Traditionally, the assumption has been that poor body image and low self-esteem are rather the consequences of bullying.

The perpetration of bullying has been examined in few studies. Obesity has predicted perpetration of bullying for boys (Griffiths et al. 2006). Results from another study showed no significant relation between weight status and being a bully but rather that the self-description of one's weight and being a bully were related (Re-

ulbach et al. 2013). Those being dissatisfied with their weight, feeling either skinny or overweight, more often reported to have bullied someone.

The stigma of obesity is related with the well-being and self-esteems of children with obesity. To ease the global obesity epidemic, this stigma demands action from health care organisations and professionals as well as from the society at large (Pont et al. 2017, Palad et al. 2019).

2.2.3 The association of overweight and obesity with learning ability and special needs in studying

Childhood obesity may weaken the financial position of later life. High BMI and obesity in late teenage years may lead to lower salaries in adulthood; lower education and occupational differences operating as mediators (Han et al. 2011). Dissimilarities of cognitive functions (Chojnacki et al. 2018), lifestyle factors such as physical activity (Hillman et al. 2015) and psychosocial factors associated with obesity (Martin et al. 2017) have been offered as mediators between obesity and academic achievements.

Obesity and cognitive functions have been shown to be related, and the association is presumably bidirectional (Smith et al. 2011). After accounting for cardiorespiratory fitness, a factor related to both obesity and cognition, adiposity remained associated with cognitive performance (Chojnacki et al. 2018). Adolescents with low academic achievements or ones altogether absent from school are more often affected by overweight than their normal weight peers (Kautiainen et al. 2009).

According to a recent review, obesity and academic achievement remain unrelated in young children, yet research supports a connection in adolescence, especially lower mathematics scores among girls with obesity (Martin et al. 2017). This is congruent with the finding that weight status at fifth grade and mathematics, reading and writing skills at sixth grade were unrelated among Canadian elementary school children (Faught et al. 2017). Instead, lifestyle factors, including diet, physical activity, sleep and screen time, were associated with school achievement one year later (Faught et al. 2017). Physical activity, sufficient sleep and a healthy diet impact learning, according to numerous studies (Jirout et al. 2019). The odds of meeting

learning expectations increased as children adopted more of these healthy lifestyle behaviours (Faught et al. 2017). Yet, research on relationships, mediators and confounders remains insufficient (Jirout et al. 2019).

Additionally, healthy eating habits, such as regular breakfast (Szajewska and Ruszczynski 2010) and multiple daily meals (Vik et al. 2010, Jääskeläinen et al. 2013), are associated with a reduced risk for overweight and obesity among children and adolescence. In Finland, regular breakfast or consuming all school lunch items remains somewhat uncommon (School Health Promotion study 2017/2019) and children tend to skip breakfast more often with age (Parikka et al. 2018). Additionally, teenagers with overweight more seldomly consume these two important meals, sleep enough and perform physical exercise than their peers with normal weight (Mäki et al. 2019a).

Adverse psychosocial consequences of obesity, such as weight-related bullying and distress from it, constitute as further possible mediators between obesity and academic achievements (Martin et al. 2017). In focus group interviews, adolescents with obesity considered that a positive attitude towards school is decisive for successful learning (Martin et al. 2017). Especially girls with obesity disliked physical exercise classes and often skipped them. Resulting negative feelings may affect their attitudes towards learning.

Special or intensified support in school offers a way to support children with learning difficulties and also with other school related challenges, for example children with visual or hearing impairments or attention or behavioural problems (Basic Education Act 628/1998). In Helsinki, between 2011 and 2018, up to 10% of primary school children received special support for their studies (Vipunen - Education Statistics Finland 2013). Special needs in studying are discussed at regular school health checks (Government decree 338/2011) and therefore usually recorded in EHRs of children.

2.3 School health care services

2.3.1 School health care services in Europe

Organisation of school health services (Baltag and Levi 2013) and weight and height monitoring programs (Davidson et al. 2018) differ between European countries due to the lack of international guidelines for these services. Possibilities for health promotion in schools have been overlooked (Baltag and Levi 2013) despite WHO launching in 1995 an initiative to improve the health of community members through schools (Global school health initiative 1995). Fortunately, WHO is currently preparing the School Health Services Guideline, the objective being to promote health of school aged children by adopting effective interventions in school health services (School Health Services Guideline 2020).

Organisational models for school health services can be classified by three elements; the presence of a dedicated school nurse or/and school doctor, statutory involvement of other health professionals and the proximity of the services (school-based/not school-based) (Baltag and Levi 2013). In a study utilising WHO questionnaire-based data on school health service organisational models among WHO European Region Member States, five organisational models arose; *dedicated school-based*, *dedicated community-based*, *integrated with primary care*, *mixed school-based and mixed community-based* (Baltag and Levi 2013). Nordic countries have mostly implemented dedicated school-based models. The Finnish model was classified as a mixed school-based model. By analysing models against their potential impact, researchers hypothesize that school-based models might better fulfil the goals for effectiveness, equity, responsiveness and efficiency.

Evaluating efficient organisational models, developing evidence-based school health services and promoting the need of school health care to policymakers are all demanding, yet necessary tasks for health promotion (Levinson et al. 2019). The environment at large affects the future health of children and the time span for measuring effects of interventions can be as much as decades (Forrest and Riley 2004). Therefore, and unsurprisingly, the effectiveness of school health services remains understudied (Levinson et al. 2019).

A life course perspective (Forrest and Riley 2004), lined with the ambitions of school health care (Government decree 338/2011), may help to discern the potential of school health care services. Support offered by school health services often benefits from being multidisciplinary. Furthermore, co-operation between health personnel and education personnel increases the success of interventions (Langford et al. 2015a). The holistic WHO Health Promoting Schools framework has had a positive influence on some aspects of children's life, including a decrease in prevalence of overweight and bullying (Langford et al. 2015b).

2.3.2 School health care in Finland

In Finland, school health services cover all school-aged children and possess great potential in supporting health equality (CSDH 2008, WHO Guideline 2017). School health care in Finland has an over 100-year history (Terho 2002) and is an important part of preventive health care. It continues screening and health promotion carried out by child health clinics (Table 2:3). The ultimate goal has always been to promote the health of school children, but the operative focus has evolved from screening and treatment of communicable diseases and undernutrition towards preventive health care.

The Primary Health Care Act from 1972 regulated that primary health is responsible for preventive health care (Primary Health Care Act 66/1972). The Health Care Act from 2010 introduced guidance for school health care (Health Care Act 1326/2010) and, moreover, the Decree for school health care (Government decree 338/2011) offers guidelines for practical actions. Also, the Basic Education Act (Basic Education Act 628/1998) and teaching-related guidance impact school health care work. School health care aims to be preventive, family oriented and multidisciplinary and, furthermore, emphasises prevention and early detection (Government decree 338/2011). Even though school health services have been legislated by law in Finland since 2011, the organization of school health care, especially the arrangement of school physician resources, differ between municipalities (Hakulinen et al. 2018). Positions of full-time school physicians are generally increasing.

During the 1990s, school health services were largely downshifted in municipalities along with the economic depression, which led to rectification actions by the

government. From 2011, the government decree has regulated school health care and directs municipalities to systematise services and arrange extensive multidisciplinary health examinations at 1st, 5th and 8th grades (Table 2:3). Additionally, school nurses are instructed to meet all children annually. Extensive health examinations include visiting the school nurse and school physician, and the importance of the presence of parents is underlined. Extra visits are offered if preventive health concerns are observed, such as mental health and growth problems or learning difficulties. The treatment of acute illnesses and long-term diseases takes place at community health centres. Overweight and obesity are viable reasons for extra school health care visits.

Table 2:3 *The health check protocol in Finland from 1 year of age onward to the end of compulsory education* (Government decree 338/2011)

Type of health check	**Child health clinic** (age in years)							**Primary school** (grade)						**Junior high school** (grade)		
	1	1.5	2	3	4	5	6	1	2	3	4	5	6	7	8	9
Annual health check by public health nurse / school nurse	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Extensive health check by public health nurse / school nurse and physician / school physician		X			X			X				X			X	

Working at school premises aids collaboration with other in-school professionals. In Finland, this multidisciplinary work is called Student welfare services (Student Welfare Act 2013) and it includes both the professionals working for educational departments, such as teachers, psychologists, school social workers, and school nurses, and the school physicians from the health care department. This arrangement of professionals from different organisational sectors challenges smooth collaboration.

In Helsinki, school nurses have one to three schools to take care of and therefore are occasionally unavailable for children. From 2004 onwards, Helsinki has had a special sector for school health care and many physicians work full-time in school health care. Since 2011, physicians from community health centre have withdrawn from school health care and all school physicians work either solely for school- and student health services or do so in addition to having a position at a child health clinic. The Quality Recommendation for School Health Care advises to have one school nurse per 600 and one physician per 2100 primary school children (Quality Recommendation for School Health Care 2004). In 2017, 88% of municipalities fulfilled the recommendation for school nurses but only 8% for school physicians, median being 3900 children per school physician (Wiss et al. 2018). This has led to a situation where school physicians visit a single school just from once a week to once a month, depending on the size of the school.

School health care services offer a place to implement international and national guidelines for obesity prevention and treatment. WHO guidance (Report of the Commission on Ending Childhood Obesity 2016, Report of the Commission on Ending Childhood Obesity 2017), the national Current Care Guideline for obesity (Obesity in children adolescents and adults: Current Care Guidelines 2020) and local recommendations are available to support the task. Screening of diseases by monitoring height and weight remains an important part of school health care, although over the past 100 years the main challenge has shifted from underweight and undernutrition to overweight and decreased physical activity.

2.4 Childhood obesity screening and treatment

2.4.1 Evidence-based practical guidelines and local recommendations

International and national evidence-based guidelines on childhood obesity support health care personnel's work (Richardson et al. 2013, Grossman et al. 2017, Report of the Commission on Ending Childhood Obesity 2017, Davidson et al. 2018, Eneli et al. 2018, Obesity in children adolescents and adults: Current Care Guidelines 2020). Additionally, guidelines are targeted at decision-makers, as prevention of

overweight and obesity requires actions from all sectors in society, and all political decisions have health effects.

Previously, the justification for population-level screening of childhood overweight and obesity has been questioned, mainly due to the lack of evidence. The rationale has been that, before organising any screening, primary prevention should be well organised and effective interventions must be made available (Westwood et al. 2007). In Finland, regular weight and height measurements have been included in child health clinics and school health care work for decades, already before the obesity epidemic. In many other countries, regular measurements have drawn more debate and national schemes for weight and height measurements after toddler age are rare (Davidson et al. 2018, Davidson et al. 2019). In 2005, US Preventive Services Task Force (USPSTF) decided not to recommend routine screening for overweight for under 12-year-old children (Whitlock et al. 2005). The task force reported that for adolescents an elevated BMI indicated an increased risk of adult obesity, but for younger children evidence of reliable risk categorisation was insufficient at the time. In many countries, weight status assessments have been commenced due to the obesity epidemic and they may encounter more concerns over the measurements than countries with a longer history of growth monitoring (Davidson et al. 2018).

With increasing knowledge on childhood obesity, we have seen a move from discussing whether to gauge BMI or not to challenges in assessing individual risks that overweight poses on later-life health (Barlow 2007, Styne et al. 2017, Juonala et al. 2020). The European Association for the Study of Obesity (EASO) sees obesity as a chronic childhood and adolescence disease and recommends early recognition and intervention (Farpour-Lambert et al. 2015). In 2017, after more research was made, USPSTF also recommended screening for overweight and obesity from 6 years of age onward (Grossman et al. 2017). In Finland, school health care is in the foreground for screening which actualises in annual observations (Government decree 338/2011). The phenomenon of less than half of parents recognising the overweight of their child (Parry et al. 2008), especially when parents themselves are affected by overweight, (Doolen et al. 2009, Vuorela et al. 2010) strengthens the need for screening.

WHO recommends countries to provide for children with obesity multicomponent services for weight management (Report of the Commission on Ending Childhood Obesity 2017). International guidelines have consensus on the need for intensive, long-lasting, family-oriented treatment methods to battle childhood obesity (Richardson et al. 2013). In particular, guidelines aim to offer tools for primary health care practitioners (Baker et al. 2010, Eneli et al. 2018, Obesity in children adolescents and adults: Current Care Guidelines 2020). Health care and educational systems differ between countries, which makes comparison challenging and impedes the implementation of guidelines. Furthermore, diagnostic classifications differ amongst national recommendations (Richardson et al. 2013).

In Finland, the national Current Care Guidelines for prevention and treatment of childhood obesity have, since their release in 2005, been updated in 2012 and 2020 (Obesity in children adolescents and adults: Current Care Guidelines 2020). Overweight, especially childhood overweight, remains a matter of the whole family and potentially continues from childhood to adulthood. To address this, the latest updated version has combined, for the first time, the guidelines for children, adolescents and adults.

2.4.2 Implementation of guidelines

Guidelines are useful only if diligently implemented. Significant goals, such as tackling the obesity epidemic, call for various actors to participate in the implementation, governments eventually bearing the responsibility to enable the process (Report of the Commission on Ending Childhood Obesity 2017). Health care has a major role, even though prevention actualises in all policies and largely outside of health care. The implementation of national guidelines, the “golden standards” of health care, is recommended to be based on local guidelines, in order to give due consideration for local actors, processes and resources.

In Helsinki, local recommendations have been regularly revised and developed, the latest revision being from 2019.

Both enhancing and preventing factors for the use of guidelines may occur. Studies have tried to identify factors enhancing the use of guidelines. Teamwork (Schro-

eder and Smaldone 2017) and definite coordination, and in some cases rearrangement, of the work seems to offer benefits (Schalkwijk et al. 2016). Finnish School health care overall has a multidisciplinary approach for work (Government decree 338/2011).

Both the implementation process and the actual use of guidelines may encounter barriers. Health care professionals feel barriers such as workload and lack of expertise and time (Turner et al. 2009, Schalkwijk et al. 2016, Schroeder and Smaldone 2017), but the most abundant and complex challenges seem to involve the co-operation and communication with families.

Overall school nurses feel uncomfortable discussing obesity with parents (Chelvakumar et al. 2014, Thorstensson et al. 2018). One reason possibly being that both nurses and general practitioners fear insulting the parents or damaging the relationship with the family (Mäenpää et al. 2013, Schalkwijk et al. 2016, Schroeder and Smaldone 2017). Health care professionals experience lack of patient compliance and motivation (Chelvakumar et al. 2014, Yeager et al. 2019). Also, different viewpoints of parents and health care professionals hamper the communication as parents might experience health checks as formalistic processes where families' own expertise will be forgotten (Mäenpää et al. 2013). Lack of parent presence at appointments as well remains a barrier for adopting the guidelines (Yeager et al. 2019).

2.4.3 Discussion of weight-related topics with families

Successful implementation of guidelines is of value, yet at the same time good rapport with families and children is crucial. As health care professionals' concerns show, fruitful communication is imperative for working with families and delivering treatments. Cultural aspects and parental perceptions need recognition (Fitzgibbon and Beech 2009). Evidence-based clinical guidelines for weight-related communication are lacking, but available evidence has been gathered in a scoping review of the literature (McPherson et al. 2017). Recommendations include raising topics regularly and with all concerned parties, discussing with strength-related words, setting goals collaboratively and using appropriate supporting material to concretise the issue. The interviewed children and parents mainly agreed with these

recommendations (McPherson et al. 2018). In Finland, the dilemma of bringing up overweight-related issues with parents has been recognised and recommendations and tools have been developed to ease the challenge (Neuvola- ja alakouluikäisen lapsen ylipainon puheeksiotto 2019).

Developing evidence-based guidelines necessitates studies evaluating the influence of communication methods on outcomes, such as parent engagement, changes in health-related habits and weight development (McPherson et al. 2018). Implementing these principles and tailoring them to different situations, populations and individuals is important and needs further studying.

2.4.4 Screening and treatment of obesity in primary health care

Practical guidelines furthermore instruct the distribution of tasks. Primary health care is generally considered the main actor for childhood obesity treatment in health care. Then again, paediatric outpatient clinics work with the most challenging cases of childhood obesity; children with comorbidities and when pharmacological or surgical treatments have to be considered (Obesity in children adolescents and adults: Current Care Guidelines 2020). School nurses are in the forefront for identifying obesity, and they play a key role in school-based treatments of childhood obesity (Schroeder et al. 2016, Thorstensson et al. 2018). The opinion of some health care professionals, that primary care is unsuitable for this work, originates from a sense of lack of time and expertise (Turner et al. 2009).

The view that school health care has major potential as a player in obesity prevention and treatment in Finland can be divided into three arguments. First, the Finnish decree on school health care (Government decree 338/2011) and programs in other European countries (Davidson et al. 2018) require health care professionals to meet and measure children regularly during school years. This enables professionals to detect unhealthy weight gain. Second, school health care aims to promote health of children and their entire families by practicing family-oriented and multidisciplinary methods at schools, close to the children. Third, the Finnish Current Care Guideline for Obesity (Obesity in children adolescents and adults: Current Care Guidelines 2020), along with other national evidence-based guidelines (Richardson et al. 2013), recognise primary health care as the main actor. Thus,

primary care physicians (Bhuyan et al. 2015) and nurses (Schroeder et al. 2016) are both potential, and possibly underused, sources for overweight-related interventions and obesity treatment.

2.4.5 Actualisation of screening and treatment of obesity in primary health care

Previous studies from the United States indicate that physicians identify overweight and obesity and offer treatments poorly during single preventive visits (Benson et al. 2009, Patel et al. 2010, O'Connor et al. 2013). Health care professionals tend to see their ability to provide care on obesity issues in a more positive light than actual documentation from EHRs indicates (Chelvakumar et al. 2014). Nevertheless, communication on overweight-related matters between health professionals and parents and adolescence has lately progressed (Hansen et al. 2016).

Eighteen to 52% of children with overweight or obesity received a diagnosis (Patel et al. 2010, O'Connor et al. 2013, Chelvakumar et al. 2014). Recognition of overweight and diagnoses show a rising trend with age (Benson et al. 2009, Patel et al. 2010), with mounting BMI (Barlow et al. 2007, Benson et al. 2009, Chelvakumar et al. 2014) as well as with increasing health care visits (Benson et al. 2009). In a study in US, treatments were initiated for under half of those identified as having an elevated BMI (O'Connor et al. 2013).

Intervention studies aiming to ameliorate health care professionals' ability to screen and treat childhood obesity also show low baseline figures for the actualisation of screening and treatment. In some studies, educational interventions have shown substantial benefits for clinical practices in paediatric primary care, where screening, diagnosis and counselling of overweight and obesity rose from an extremely low level of 3% to over 80% (Meropol et al. 2014, Gibson 2016). Yet, according to a systematic review, interventions targeted at health care professionals for promoting obesity prevention and treatment have achieved only moderate improvements in clinical practices, and only a minor and uncertain amelioration of treatment results (Flodgren et al. 2017).

As health care systems differ among countries, studies made in US and Australia offer only an assumption of the situation in Finland. Therefore, researchers and practitioners may be unaware how screening and treatment of overweight and obesity among school aged children actualises in primary health care both abroad and in Finland. Cross-sectional studies merely monitor single visits instead of the end-to-end treatment process. Longitudinal data from unselected populations could offer a broader view on the situation, but studies with such setups are scarce.

2.4.6 Treatment outcomes

Since the Cochrane systematic review from 2009, family-based combined interventions including diet, physical activity and behavioural components are recommended as an evidence-based practice in treating childhood obesity (Oude Luttikhuis et al. 2009). The review has lately been updated and divided into six sections: diet, physical activity, and behavioural interventions for 1) young children up to the age of six years (Colquitt et al. 2016), 2) schoolchildren aged 6 to 11 years (Mead et al. 2017), 3) adolescents aged 12 to 17 years (Al-Khudairy et al. 2017) as well as 4) parent-only interventions (Loveman et al. 2015), 5) surgery (Ells et al. 2015) and 6) drug therapy (Mead et al. 2016).

Obesity interventions can be classified according to 1) content: physical activity interventions, dietary interventions, education-based interventions, pharmacological interventions, surgical interventions and combined approaches, 2) setting: school-based interventions, family-based interventions (either parent-child or parent only), 3) professionals involved: school nurse, physician, dietitian, teachers or multidisciplinary and 4) target group: individuals or organised as group interventions (Rajjo et al. 2017).

Several treatment methods for childhood obesity might be effective at least in the short term, although results overall may be modest (Mead et al. 2017, Rajjo et al. 2017). Multicomponent behaviour-modification interventions may offer best results without adverse effects (Mead et al. 2017). To treat primary school aged children with obesity, family- and group based multicomponent interventions have been shown effective both in Finland with a 1-year follow-up (Kalavainen et al. 2007) and in Sweden with a 5-year follow-up (Danielsson et al. 2016). Unfortu-

nately, the benefit of group-based interventions compared with routine counselling faded away during 2 and 3-year follow-ups of the Finnish study (Kalavainen et al. 2011). Additionally, around half of the families discontinued treatment in the Swedish study, a majority of them by the parents' decision (Danielsson et al. 2016). Appetite awareness training can play an effective role in family-based interventions, as it led to better results in a 2-year follow-up (Njardvik et al. 2018).

The Council for Choices in Health Care in Finland (COHERE Finland) evaluates cost-effectiveness and recommends treatments and interventions to be offered in publicly financed health services. In September 2020 it launched recommendations for life-style interventions (COHERE Finland 2020). The Neuvokas perhe -program (Neuvokas perhe 2020) was found to be effective by COHERE and was recommended as a life-style intervention for children and families. Life-style interventions are advocated to include certain elements: baseline evaluation, communication, targets, treatment plan, follow-up and feedback and, lastly, they are to be individualized according to the needs of children, families and patients (COHERE Finland 2020).

Greater adult involvement, guidance for parents to take responsibility for the family life-style environment and assumed lower cost have led to the development of parent-only interventions (Loveman et al. 2015). This option is recommended, when appropriate, for primary school age children, as these parent-only interventions can be as effective as parent-child interventions (Loveman et al. 2015). It is noteworthy that physical interventions alone remain ineffective for weight loss for children (Rajjo et al. 2017).

For a desirable outcome, patient- and family-related aspects, such as age, motivation and socioeconomical status, would appear even more important than the actual treatment method. These are possible sources for bias when comparing different treatment methods. Some of these aspects are the same as factors predicting childhood obesity development (Juonala et al. 2020). For example, paediatric outpatient clinics have obtained results in treating severe obesity; top results noted were for under 10-year-olds when the children and families were both motivated and adhered well to the protocol (Dalla Valle et al. 2017). Similarly, multidisciplinary

care management programs for treating obesity had better outcomes if the follow up continued for over 10 months, children participated in organized sports, parents were unaffected by obesity and children lacked academic difficulties (Carriere et al. 2016). On the contrary, a Norwegian study on family-oriented multidisciplinary interventions for 5-years-olds, with a 3-year follow-up, failed to identify effects on BMI SDS (Donkor et al. 2019).

As primary care stands as the main actor, outcomes of paediatric weight management interventions in primary care settings are of special importance. These interventions can be effective (Sargent et al. 2011, Mitchell et al. 2016) and a review found modest support for them (Seburg et al. 2015). Longer duration, more contacts overall and more contacts by a paediatrician were associated with better results (Mitchell et al. 2016). Similarly, a multicomponent and behaviour-change targeted approach with tailored intensity was found useful (Sargent et al. 2011).

Primary care physicians can play a significant role in obesity prevention and treatment by incorporating interventions into regular clinical appointments and, in addition to screening obesity, advocating healthy lifestyles (Bhuyan et al. 2015). Identically, it seems that school nurses remain underused in obesity prevention and interventions (Schroeder et al. 2016). To further develop childhood obesity interventions, information is needed on the sustainability of treatment results, translating to a demand for evidence from follow-ups lasting over six months (Mead et al. 2017). Additionally, cost-effectiveness (Loveman et al. 2015), health-related quality of life and possible adverse effects (Mead et al. 2017) of treatments all require further studies.

2.5 Summary of the literature

Childhood obesity is increasing worldwide, and it potentially continues to adulthood, even though most adults with obesity today have been in normal weight area during childhood. Health care has a major role in screening and treatment of obesity. However, obesity development largely originates from changes in the surroundings children are living in. Therefore, also the prevention of obesity needs to be integrated into all policies.

Growing amounts of comparable data on prevalence are becoming available. Nonetheless, incidence and resolution rates along with development patterns remain understudied. Especially, the relations of overweight development to psychosocial characteristics and offered interventions need further studies.

The organisation of primary health care and screening processes for childhood overweight vary between countries. In Finland, school health services play a major role in childhood obesity prevention and treatment and they have potential to offer even more. School nurses and physicians appreciate their opportunities for prevention and treatment, yet obstacles exist, and many aspects of their work methods could be developed. The main question, whom to target and at what age, stands.

The development of a child's overweight or obesity depends on many factors, as do the results of treatments. Obesity interventions seem be effective, although study results differ, and long-term follow-ups are scarce. Multicomponent and multidisciplinary family-oriented methods seem to offer best results and can be organised by school health care. Identifying those at risk of developing non-resolving obesity, and therefore at need for more support, is crucial. The BMI of the child and her mother, in addition to her mother's education level, are strong predictors for childhood obesity. Beside these early-life predictors, also overweight-related factors that can be identified by school health care and supported by school personnel remain valuable to notice.

3 AIMS OF THE STUDY

This study aimed to analyse overweight development of children over primary school years and to identify psychosocial factors associated with childhood obesity. The study also detected to whom and at which overweight development state school nurses and physicians offered overweight-related interventions.

The specific aims of the study were:

1) To retrospectively analyse the continuity of childhood overweight and obesity before and over primary school years and to find psychosocial factors identifiable by school health care and being associated with childhood obesity (Study I).

2) To evaluate the competence of school nurses and school physicians in identifying and diagnosing obesity and offering obesity-related interventions, as compared to national recommendations (Study II).

3) To identify groups of children with similar age-related patterns of overweight development and to analyse overweight-related interventions offered to them (Study III).

4) To assess the probability of moving from a weight category to another during primary school, to analyse these transitions by age and gender and to detect associations between psychosocial characteristics and transition rates (Study IV).

4 SUBJECTS AND METHODS

This longitudinal cohort study exploited retrospective electronic health record (EHR) data to analyse childhood weight development as well as screening and treatment of overweight and obesity in school health care. In December 2012, the Department of Health Care of Helsinki approved the conducting of the study. The city's Education Department delivered data on all 4968 sixth graders studying in Helsinki in April 2013. No ethical approval was required for this pure register-based study. A random selection of 2000 of these 4968 primary school students became the study cohort (Figure 4:1).

The 4968 social security numbers were given an ID number from 1 to 4968 in the order the data was received. 2000 children were chosen for the study by acquiring 2000 integers between 1 and 4968 with a random number generator. After opening the EHRs, it was noticed that the social security numbers were in alphabetical order by the last name of the child.

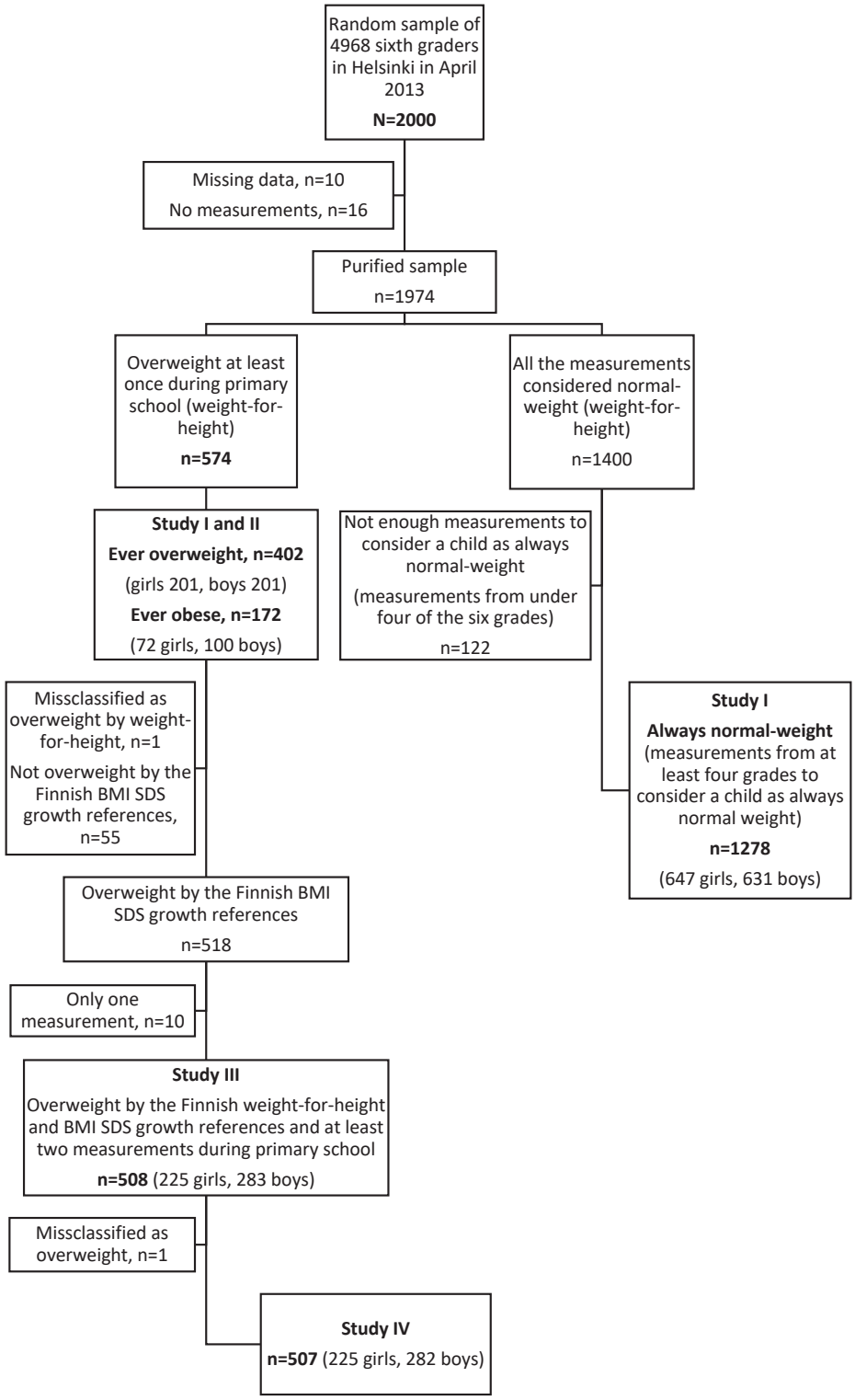


Figure 4:1 *The flow chart of the study population. Overweightness includes obesity.*

4.1 Subjects in studies I-IV

Of the cohort of 2000 sixth graders, the growth charts of 1974 children were available in the "Pegasos" EHR, which was used by Helsinki primary care in 2013. The children were incorporated into the study according to their weight status and their highest weight category during the six primary school years. Figure 4:1 shows the flow chart for assembling the study population.

Weight and height measurements are routine elements in school health care visits and most often assessed by school nurses. Practical guidelines for school health care (Mäki et al. 2017b) instruct their measuring. Measurements are taken once but repeated if the growth curve is seen to bend downward or upward. Values are entered in centimetres rounded to the first decimal.

The assessment of pubertal stage is also included in annual school health care visits (Mäki et al. 2017b). It is customary for school nurses to enter information on a possible menarche and often also the development stage of the mammary gland by Tanner staging (Marshall and Tanner 1969). Nevertheless, school physicians enter the results of a comprehensive Tanner staging after physical examinations (Marshall and Tanner 1969, Marshall and Tanner 1970).

4.1.1 Assessment of the weight status and weight category

For the initial analyses, weight statuses were determined by the Finnish weight-for-height reference which presents weight as a percentage of the median weight of children of same height and gender (Sorva et al. 1984). Weight-for-height was adopted as the primary reference instead of international references, as it was the national standard during the study period. Finnish school health care personnel analysed children's growth and defined needs for overweight-related interventions by it. For the cohort of 2000 children, growth charts were inspected to check had the children been affected by overweight or obesity during primary school or between 1 to 6 years of age when under the observation of child health clinics. If they had had only normal weight in measurements, the count of normal weight measurements during child health clinic visits and, separately, over primary school were registered.

In this study, cut-offs for overweight and obesity were taken from the Finnish weight-for-height references, being 120% (overweight) and 140% (obesity) of the median weight of boys or girls of the same height for children aged 7 or more, and 110% and 120%, respectively, for children below 7 years of age (Sorva et al. 1984). Revised Finnish growth references and BMI-for-age classifications for overweight and obesity were launched in 2011 (Saari et al. 2011) and adopted to EHR in Helsinki in 2016. In studies III and IV, where trajectories of overweight and obesity development as well as probabilities to move from a weight category to another were analysed, the new growth references were applied, including BMI SDS values. The revised standard sets BMI SDS cut-offs for overweight for girls at 1.1629 and boys at 0.7784, and for obesity 2.1065 and 1.7016, respectively.

By the weight-for-height classification, 574 of the 2000 children were affected by overweight or obesity at least once during primary school. The weight development of these 574 children was studied in detail. For later analyses, their weight measurements were converted into BMI SDS using the new Finnish BMI-for-age growth references (Saari et al. 2011). The overall maximum weight category, maximum weight category at each school grade, overall maximum and minimum BMI SDS, and BMI SDS and categories in the beginning and at the end of the follow-up were defined. The 574 children were additionally classified utilizing the IOTF criteria (Cole et al. 2000). The overall weight category and weight categories at each school grade, defined by weight-for-height, IOTF and BMI SDS classifications, were all compared with each other.

4.1.2 Inclusion criteria

For Study I, children were classified as *Ever Overweight* or *Ever Obese* in primary school if a child had been affected by overweight or obesity at least once during the six primary school grades, as assessed by the national weight-for-height classification. In order to have been classified as *Always Normal Weight*, a child needed to have four or more normal weight measurements during primary school.

From the random sample of 2000 6th graders, the weight categories *Ever Obese*, *Ever Overweight* or *Always Normal Weight* could be defined for 1852 children (920 girls and 932 boys). Of these, the weight category before school age was identifi-

able for 1563 children. In total, 402 *Ever Overweight* (21,7%, 201 girls, 201 boys, excluding obese), 172 *Ever Obese* (9,3%, 72 girls, 100 boys) and 1 278 *Always Normal Weight* (69%, 647 girls, 631 boys, including underweight) children were identified for comparison in studies I and II (Figure 4:1).

The classification into normal weight, overweight or obesity before school age (1-6 years of age) was made similarly; a child had to have at least four exclusively normal weight measurements to be classified as *Always Normal Weight*, and one or more measurements of overweight or obesity was enough for classification into overweight or obesity. These study subjects in different combinations formed the study samples for the four sub-studies (Figure 4:1).

In Study I, the whole cohort of 1852 children (574 ever-overweight or ever-obese and 1278 always normal weight) was included in the analyses of weight category continuity. In a separate analysis, psychosocial characteristics of *Ever Overweight* and *Ever Obese* groups were compared. The prevalence and incidence of obesity at the six primary school grades were analysed among the 172 children affected by obesity. As one boy was later found to have been incorrectly classified as overweight, analyses from Study II onward were made among 573 children. The 172 children affected by obesity at some point (72 girls and 100 boys) concluded the study sample in Study II, as the objective was to understand obesity treatments offered in school health care.

Of the 573 children, 518 were affected by overweight or obesity at least once during primary school both by the weight-for-height (Sorva et al. 1984) and by the new Finnish BMI-for-age (Saari et al. 2011) growth references. To enable analysis of overweight trajectories during primary school, a child had to have more than one measurement entered in EHR. The study sample in Study III consisted of 508 children (225 girls and 283 boys), each with at least two growth measurements and who had overweight by both references applied. When analysing the growth measurement data of the 508 children for the Study IV, one weight measurement of a boy earlier classified in the obesity class was noticed to most probably have been entered incorrectly into EHR. This individual was excluded from the study sample, leading to 507 children in Study IV.

4.2 Variables in studies I-IV

Data on gender and the child's overall weight category before school age (1 to 6 years of age) and during primary school (grades 1 to 6) were collected for the whole cohort of 1852 children. Subsequently, for the 574 children in *Ever Overweight* or *Ever Obese* classes, all the EHR entries were examined. Entries of interest comprised of background and psychosocial characteristics, if available, as well as of annual health checks and any extra visits to school health care.

The manually collected retrospective data from these entries included, in addition to growth measurements, aspects that could be related to a child's weight development, such as overweight-related psychosocial family- and school-related characteristics and overweight-related interventions offered during primary school years. Data from EHRs were collected as comprehensively as possible, noting original inscriptions, and classified using multiple choices. For many variables in the study, the information needed was gathered from multiple entries combining data collected earlier. The categorisation of variables was formed according to the current research question in each sub-study. Table 4:1 presents the variables with their definitions and appearances in the four sub-studies.

4.2.1 Study I

Study I analysed the weight status data of all 1852 children in classes *Always Normal Weight*, *Ever Overweight* or *Ever Obese* during primary school. These were compared with the weight category of the child (normal weight, overweight or obesity) before school age (from 1 to 6 years of age). Additionally, psychosocial characteristics of the children in *Ever Overweight* (n=402) and *Ever Obese* (n=172) classes were compared. Variables used were gender, special needs in studying, bullying, contacts with psychiatric care, family crises, family structure and whether one or both parents were non-native Finnish or Swedish speakers. Data on these variables were consolidated from all the recordings during the six primary school years.

4.2.2 Study II

In Study II, the sample consisted of the 172 *Ever Obese* children. The count and content of annual and multidisciplinary extensive health checks as well as overweight-related extra visits to school health care during primary school were analysed. The collected content from health checks included treatment plans, information on whether the health check was made together with parents, and recorded consultations and referrals due to overweight. EHR entries of weight challenges and of obesity diagnoses made by school physicians were retrieved as well. Treatment plans were allotted into follow-up plans, concrete plans for nutrition or exercise, and weight development targets. Information on whether treatment plans were made together with the child's parents was included as a dichotomous variable.

Data on actualised health checks, treatment plans and offered interventions were analysed per every school grade. To form an overall picture of the level of intervention, these data were consolidated as single variables from all the recordings during six primary school years. Data on treatment plans and offered interventions were gathered from entries of both school nurses and school physicians, as they work as a team. Some variables were modified to capture information on interventions offered after the child had been measured having obesity for the first time during primary school. These variables were counted for the 157 children who were affected by obesity before the sixth grade.

4.2.3 Study III

Study III identified distinct latent classes of overweight development during primary school and formed sex-specific overweight development trajectories. Weight-related attributes, such as the highest and the lowest BMI SDS during primary school and the age of a child at the time, were calculated for latent classes in order to ascertain whether their distribution was congruent with the trajectories and in order to portray the children of different latent classes.

For the consideration of the effects of pubertal development, data from across all entries in EHRs were gathered to form a variable depicting early, average or late pubertal development of girls. Similarly, some of the boys could be classified into a

group of early pubertal development. Because children commonly were between 11 and 12 years of age during their 5th grade health check, definitions on average or late pubertal development were unattainable for boys. Therefore, the remaining boys were labelled by pubertal development having started or not by the time of the 5th grade health check. The criteria for these classifications are explained in Table 4:1.

For the analyses of associations between overweight-related interventions and weight development trajectory classes, variables for overweight-related interventions were formed indicating interventions offered by school health care after the first overweight or obesity measurement during primary school. A new dichotomous variable *Optimal Intervention* was established from these variables to indicate whether the overall treatment effort could be assumed adequate. In addition, information on consultations with dietitians and physiotherapists, obesity diagnoses entered by school physicians and involvement in regular and guided sport activities were gathered.

Children were considered to have received *Optimal Intervention* if all the following existed: 1) an observation of overweight or obesity in EHR by school nurse, 2) a routine health check by school physician or appointment due to overweight or obesity, 3) a treatment plan together with parents and 4) a plan for a next overweight-related appointment. In addition to these, for *Optimal Intervention*, a recording had to have been made for 5) a concrete nutrition or exercise plan or 6) an accomplished and recorded positive change in health habits. Children were considered to have received *Optimal Intervention* if they attended family centred group interventions over a duration of a school year or visited paediatricians in outpatient clinics due to obesity.

4.2.4 Study IV

Study IV analysed weight category transitions in relation to psychosocial family- and school-related factors of the children. The factors that were included were ones that are presumably related to overweight development, distinguishable in EHRs and likely to remain constant during primary school years. Dichotomous family-related variables were: 1) family structure 2) one or both parents being non-na-

tive for Finnish or Swedish and 3) crises in family. School-related variables applied were: 4) special needs in studying and 5) bullying. The timing of pubertal development was also used as a covariate. All variables and their definitions are pictured in Table 4:1.

4.3 Statistical methods in studies I-IV

Categorical data on the psychosocial characteristics, actualized school health checks, overweight-related interventions and weight-related attributes of the study population as well as latent classes were presented as counts and percentages and continuous variables, as they were not normally distributed, as medians and interquartile ranges (IQR).

In Study I, differences in categorical variables between *Ever Overweight* and *Ever Obese* children were evaluated using Chi-square test for independence.

In Study II, where the school health care professionals' ability to screen and intervene was examined, the offered interventions were presented as descriptive statistics by displaying counts and percentages.

To identify groups of children with similar weight development, in Study III, BMI SDS was studied along with age. The weight development trajectory classes were fitted using latent class mixed model (Proust-Lima et al. 2017) for R statistical software version 3.5.0 (R-project 2017). This flexible LCMM method by Proust-Lima enabled utilizing the varying count and timing of measurements per child retrieved from EHRs. The analysis followed the suggested framework for LCMM (Lennon et al. 2018) and previous evaluations of the method (Kamata et al. 2018). Study III examined whether the overweight-related interventions offered were associated with latent classes. To test these associations and unveil whether weight-related attributes were congruent with the conceived weight development curves, Fisher's exact test was adopted for categorical variables and, for continuous variables, the non-parametric Kruskall-Wallis test.

Study IV utilized Markov multistate models (msm) (Jackson 2011) for the at some point overweight primary school children to estimate transition rates (transition

intensities) between the weight categories of normal weight, overweight and obesity. The 3-state model examined 4 transitions: normal weight to overweight and vice versa, and overweight to obesity and vice versa. From these transition rates, 1-year probabilities to move from a weight category to another, the mean sojourn time spent at each category at one visit, and the total length of time spent in each category during the study period were estimated. The relation between psychosocial family- and school-related factors and transition rates during primary school were examined by univariate and multivariable proportional intensities models. The analyses in Study IV were conducted with the msm-library available in R (R-project 2017, Jackson 2011).

IBM SPSS versions 21, 23 and 25 software (IBM corporation, Armonk, New York, USA) were used for other than latent classes (LCMM) or Markov multistate models (msm) statistical comparisons.

Table 4:1 *Variables used in studies I-IV*

	Study I	Study II	Study III	Study IV	Definition of the variable
Weight development					
WEIGHT CATEGORY AT 1-6 YEARS OF AGE	Weight-for-height classification: Overweight (at least once) / Obesity (at least once) / Normal weight (at least four normal weight measurements)	–	–	–	Classification by the weight-for-height reference. Overweight: weight ≥110% of the median weight of boys or girls of the same height. Obesity: weight >120%
WEIGHT CATEGORY DURING PRIMARY SCHOOL	Weight-for-height classification: *Ever Overweight* (overweight at least once) / *Ever Obese* (obesity at least once) / *Always normal weight* (at least four normal weight measurements)	Weight-for-height classification: Obesity (at least once)	Overweight (includes obesity): one or more measurements at least overweight by weight-for-height classification and by BMI SDS classification and at least two measurements during primary school	Overweight (includes obesity): one or more measurements at least overweight by weight-for-height classification and by BMI SDS classification and at least two measurements during primary school	Classification by the weight-for-height reference. For under 7-year old children: Overweight: weight ≥110% of the median weight of boys or girls of the same height. Obesity: weight >120%. From 7 years of age: ≥120% and >140%, respectively. BMI-for-age classification: BMI SDS cut-offs for overweight (girls 1.1629, boys 0.7784) and obesity (girls 2.1065, boys 1.7016)
WEIGHT CATEGORY AT DIFFERENT SCHOOL GRADES DURING PRIMARY SCHOOL	1) Count of school grades during which the child was affected by overweight or obesity 2) The school grade at which the child was affected by obesity for the first time	–	–	–	Classification by the weight-for-height reference. For under 7-year old children: Overweight: weight ≥110% of the median weight of boys or girls of the same height. Obesity: weight >120%. From 7 years of age: ≥120% and >140%, respectively

LATENT CLASSES OF WEIGHT DEVELOPMENT DURING PRIMARY SCHOOL	–	–	Five classes for girls: *Transitory Overweight / Increasing to Overweight / Stable Overweight /Fluctuating Obesity / Decreasing Obesity*. Four classes for boys: *Transitory Overweight / Increasing to Overweight / Stable Overweight / Stable Obesity*	–	BMI-for-age classification: BMI SDS cut-offs for overweight (girls 1.1629, boys 0.7784) and obesity (girls 2.1065, boys 1.7016). Classes defined by Latent Class Mixed Models
HIGHEST BMI SDS	–	–	Numerical variable, interval scale	–	Maximum BMI SDS measurement during primary school
AGE AT HIGHEST BMI SDS	–	–	Numerical variable, ratio scale	–	Age (decimal years) at maximum BMI SDS measurement during primary school
LOWEST BMI SDS	–	–	Numerical variable, interval scale	–	Minimum BMI SDS measurement during primary school.
AGE AT LOWEST BMI SDS	–	–	Numerical variable, ratio scale	–	Age (decimal years) at minimum BMI SDS measurement during primary school
DIRECTION OF THE CHANGE OF BMI SDS DURING PRIMARY SCHOOL	–	–	Binary variable: Increased / Not increased	–	The direction of the change between the first and last growth measurements recorded in EHR during primary school
FOLLOW-UP TIME	–	–	Numerical variable, ratio scale	–	Time (decimal years) between the first and last growth measurements recorded in EHR during primary school

WEIGHT CATEGORY IN THE BEGINNING AND IN THE END OF PRIMARY SCHOOL	–	–	–	Weight category of normal weight, overweight or obesity according to the first and last BMI SDS measurements during primary school / BMI SDS measurements at grade 1 and 6 / BMI SDS measurements at the age of 7 and 12	BMI-for-age classification: BMI SDS cut-offs for overweight (girls 1.1629, boys 0.7784) and obesity (girls 2.1065, boys 1.7016)
TRANSITION BETWEEN WEIGHT CATEGORIES	–	–	–	1) Transition rates and 2) 1-year probabilities of moving between weight categories (normal weight, overweight and obesity). 2) The mean sojourn time. 3) The estimated total time spent at weight categories during primary school years	BMI-for-age classification: BMI SDS cut-offs for overweight (girls 1.1629, boys 0.7784) and obesity (girls 2.1065, boys 1.7016). Variables defined by Markov multistate models
Background characteristics					
GENDER	Binary variable: Girl / Boy	Binary variable: Girl / Boy	Binary variable: Girl / Boy	Binary variable: Girl / Boy	Girl or boy defined from social security number
PUBERTAL DEVELOPMENT	–	–	Girls: Early / Average / Late. Boys: Early / Started / Not started (by the 5th grade health check)	Girls: Early / Average / Late. Boys: Started / Not started (by the 5th grade health check)	Girls: Early (menarche or M4 by 5th grade health check), Average (M2 or M3 at grade 5 or menarche between health checks at grade 5 and 6), Late (M1 at grade 5, M2 at grade 5 but over 11.5-years-old and no menarche at grade 6 or no menarche by 13.5 years of age). Boys: Early (Tanner stage G3 or more by the time of 5th grade health check. Started (G2 at 5th grade health check), Not started (G1 at 5th grade health check)

INVOLVEMENT IN REGULAR, GUIDED SPORT ACTIVITY	–	–	Binary variable: Actualised / Not actualised (at some point during primary school)	–	One or more EHR entry on involvement in regular and guided sport activities during primary school
CONTACT TO PSYCHIATRIC CARE	Binary variable: Yes / No	–	–	–	Recorded information on specialised psychiatric care during primary school years. Information on actualised care versus information on not actualised and unsure or no information. Includes diagnosis and treatment of adhd
Family-related characteristics					
FAMILY STRUCTURE	Divorced or single parents / Married or cohabiting parents/ Family structure not known	–	–	Divorced or single parents / Married or cohabiting parents/ Family structure not known	Recorded information on family structure. Divorced or single: if parents' divorce or single parent status was mentioned at latest in the 6th grade health check. Married or cohabiting: if this could be confirmed at some point and a divorce was not mentioned later. Family structure not known: no information on family structure recorded in EHR
ONE OR BOTH PARENTS NON-NATIVE FINNISH OR SWEDISH SPEAKERS	Binary variable: Yes / No	–	–	Binary variable: Yes / No	Parents were counted as native speakers of Finnish or Swedish if there were no confirmed information in any of the EHR entries indicating otherwise (no single predefined entry in EHR exists)
FAMILY CRISIS / CRISES	Family crisis: 1) Binary variable: Yes / No 2) Count of different crises	–	–	Crises: Binary variable: Yes / No	Any of the following situations mentioned at least once in primary school health checks: domestic violence, contacts to child protection services, mental health problems or drug or alcohol abuse of parents, legal disputes over child custody, sexual harassment of a child or death of a parent or sibling

School-related characteristics					
SPECIAL NEEDS IN STUDYING	Binary variable: Yes / No	–	–	Binary variable: Yes / No	Any of the following mentioned at least once in primary school health checks: various forms of special education (performed in regular classes, special education classes or schools for special education), delayed starting of school, repeating a class or preparatory instruction classes for immigrants
BULLYING	Binary variable: Yes / No	–	–	Binary variable: Yes / No	School nurse or school physician entered information on the children's experiences in being bullied (found in EHR entries from one or more of the grades)
Health checks or overweight-related visits					
HEALTH CHECK BY SCHOOL NURSE	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school)	Binary variable: Actualised / Not actualised (at least once after the child had been affected by overweight or obesity for the first time during primary school)	–	School nurse had made an annual health check and entered information and contents of it in EHR
OVERWEIGHT-RELATED EXTRA VISITS TO SCHOOL NURSE	–	Count of visits	–	–	Child or family had visited school nurse for an extra overweight-related visit and school nurse had entered information and contents of it in EHR
HEALTH CHECK BY SCHOOL PHYSICIAN	–	Binary variables: Actualised / Not actualised (at first grade / at fifth grade / at first and fifth grades)	Binary variables: Actualised / Not actualised (at first grade / at fifth grade)	–	School physician had made a health check and entered information and contents of it in EHR

OVERWEIGHT-RELATED EXTRA VISITS TO SCHOOL PHYSICIAN	–	Count of visits	Binary variable: Actualised / Not actualised (overweight-related visit or a health check at 2nd, 3rd or 4th grade)	–	Child or family had visited school physician for an extra overweight-related visit or extra health check and school physician had entered information and contents of it in EHR
HEALTH CHECK OR OVERWEIGHT-RELATED EXTRA VISITS TO SCHOOL PHYSICIAN	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school)	1) Binary variable: Actualised / Not actualised (at 2nd, 3rd or 4th grade). 2) A part of the *Optimal Intervention* variable	–	See the two previous definitions
NORMAL HEALTH CHECK OR OVERWEIGHT-RELATED EXTRA VISITS TO SCHOOL PHYSICIAN OR SCHOOL NURSE	–	Count of school grades when actualised	Numerical variable, ratio scale: visits on average per one school grade from the grade the child had been affected by overweight or obesity for the first time during primary school	–	Study II: school nurse or school physician had made an annual health check, or a child had an overweight-related visit and school nurse or school physician entered information and contents of it in EHR. Study III: visits on average per one school grade from the grade the child had been affected by overweight or obesity for the first time during primary school until the school grade when the last growth measurement was entered in EHR during primary school (count of visits divided by count of school grades)

Interventions during primary school					
TREATMENT PLAN MADE	–	1) Count of school grades when actualised. 2) Binary variable at each school grade: Made / Not made (to those measured obese and met by school health care personnel)	–	–	Consolidated from EHR entries of school nurses and school physicians at each school grade. Treatment plan was either a follow-up plan, a concrete nutrition plan or a concrete exercise plan or a referral due to overweight or a combination of these
TREATMENT PLAN MADE TOGETHER WITH PARENTS	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school). 3) Binary variable at each school grade: Made / Not made (to those measured obese and met by school health care personnel)	A part of the *Optimal Intervention* variable. Binary variable: Actualised / Not actualised (at least once after the child had been affected by overweight or obesity for the first time during primary school)	–	A plan was considered to be made together with parents if at least some part of the treatment plan made during a school year was agreed with parents either during an appointment or by phone. Consolidated from EHR entries of school nurses and school physicians at each school grade. Treatment plan was either a follow-up plan, a concrete nutrition plan or a concrete exercise plan or a referral due to overweight or a combination of these
TREATMENT PLAN MADE, INCLUDES CONCRETE EXERCISE PLAN	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school). 3) Binary variable at each school grade: Made / Not made (to those measured obese and met by school health care personnel)	A part of the *Optimal Intervention* variable. Binary variable: Actualised / Not actualised (at least once after the child had been affected by overweight or obesity for the first time during primary school)	–	Consolidated from EHR entries of school nurses and school physicians at each school grade. Overweight related new or already started plan which increased daily activity or the amount of exercise or reduced sedentary time. Discussions or enquiries on exercise or giving general recommendations did not amount to concrete plans. Exercise plan included referral to a family-centred group intervention with weekly exercise. Plans had to be made and agreed with the child or parents

TREATMENT PLAN MADE, INCLUDES CONCRETE NUTRITION PLAN	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school). 3) Binary variable at each grade: Made / Not made (to those measured obese and met by school health care personnel)	A part of the *Optimal intervention* variable. Binary variable: Actualised / Not actualised (at least once after the child had been affected by overweight or obesity for the first time during primary school)	–	Consolidated from EHR entries of school nurses and school physicians at each school grade. Overweight related new or already started concrete plans. Discussions or enquiries on nutrition or giving general recommendations did not amount to concrete plans. Nutrition plan included consultations with dietitians. Plans had to be made and agreed with the child or parents
TREATMENT PLAN MADE, INCLUDES CONCRETE EXERCISE OR NUTRITION PLAN OR BOTH	–	1) Count of school grades when actualised. 2) Binary variable at each grade: Made / Not made (to those measured obese and met by school health care personnel)	–	–	See two previous definitions
TREATMENT PLAN MADE, INCLUDES FOLLOW-UP PLAN	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school). 3) Binary variable at each school grade: Made / Not made (to those measured obese and met by school health care personnel)	A part of the *Optimal Intervention* variable. Binary variable: Actualised / Not actualised (at least once after the child had been affected by overweight or obesity for the first time during primary school)	–	Consolidated from EHR entries of school nurses and school physicians at each school grade. Plans for extra visits to school nurses or school physicians or plans for re-evaluate the situation at the next annual school health check. Either a scheduled follow-up or an explanation why it was not needed was recorded in EHR

TREATMENT PLAN MADE, INCLUDES CONCRETE EXERCISE OR NUTRITION PLAN OR BOTH AND A FOLLOW-UP PLAN	–	Count of school grades when actualised	–	–	See four previous definitions
TREATMENT PLAN MADE, INCLUDES WEIGHT DEVELOPMENT TARGETS	–	1) Count of school grades when actualised. 2) Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school)	–	–	Either school nurse or school physician had entered weight-related targets into EHR, and these were discussed and agreed with the child or parents
POSITIVE CHANGE IN HEALTH HABITS RECORDED	–	–	A part of the *Optimal Intervention* variable. Binary variable: Actualised / Not actualised (at least once after the child had been affected by overweight or obesity for the first time during primary school)	–	Either school nurse or school physician had entered into EHR an actualised positive change in health habits. Includes: changes made in nutrition, in exercise, in sleep time, in reducing sedentary time or positive changes in mental health or in attitudes towards making changes in near future

CONSULTATION WITH DIETITIAN: A SUGGESTION, A REFERRAL OR AN ACTUALISED VISIT	–	1) Categorical variable, nominal scale: A referral by school nurse / A referral by school physician / Not made but suggested / Made before school age or from elsewhere. 2) Binary variable: Actualised / Not actualised (a referral at least once after the child had been affected by obesity for the first time during primary school). 3) Binary variable at each school grade: a referral Made / Not made (to those measured obese and met by school health care personnel)	Binary variable: Actualised / Not actualised (a visit at least once in primary health care during primary school)	–	Study II: Consultation was either suggested and this was mentioned in the free text or the referral for consultation was made by school nurse or school physician. Referrals before school age or if made by some other than school health care personnel were also noticed for the categorical variable but not for the binary variables. Study III: a visit to dietitian actualised in primary health care during primary school and there was an entry in EHR made by a dietitian
CONSULTATION WITH PHYSIOTHERAPIST	–	Binary variable: Actualised / Not actualised (a referral at least once after the child had been affected by obesity for the first time during primary school)	Binary variable: Actualised / Not actualised (a visit at least once during primary school for any reason)	–	Study II: referrals made and recorded in EHR by school nurse or school physician during primary school due to obesity. Study III: a visit to physiotherapist actualised in primary health care during primary school and there was an entry in EHR made by a physiotherapist

REFERRAL OR VISIT TO PAEDIATRICIANS IN OUTPATIENT CLINICS DUE TO OVERWEIGHT	–	1) Categorical variable, nominal scale: Referral by school physician / Referral not made but suggested / Made before school age or from elsewhere. 2) Binary variable: Actualised / Not actualised (referral at least once after the child had been affected by obesity for the first time during primary school)	A part of the *Optimal Intervention* variable. Binary variable: actualised or not (visit at least once during primary school)	–	Study II: referral was either suggested and this was mentioned in free text or a referral was made by school physician during primary school. Referrals before school age or if made by some other than school physician was also noticed for categorical variable but not for the binary variable. Study III: actualised visit to paediatricians due to overweight during primary school
FAMILY-CENTRED GROUP INTERVENTIONS: RECOMMENDATION, REFERRAL OR ACTUALISED PARTICIPATION	–	1) Binary variables: Actualised / Not actualised (recommendation or referral at least once during primary school / at least once after the child had been affected by obesity for the first time during primary school). 2) Binary variable at each school grade: Made / Not made (recommendation or referral to those measured obese and met by school health care personnel)	A part of the *Optimal Intervention* variable. Binary variable: Actualised / Not actualised (participation during primary school)	–	Either school nurse or school physician has entered a recommendation or referral for participation or entered information in EHR that the family has participated at least in some degree to family-centred group intervention.

REFERRAL TO LABORATORY TESTS	–	Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school)	–	–	Either school nurse or school physician has made a referral to laboratory tests due to obesity
SCHOOL PHYSICIAN'S OBESITY-RELATED EHR ENTRY	–	Binary variables: Actualised / Not actualised (at first grade / at fifth grade / at least once after the child had been affected by obesity for the first time during primary school)	–	–	School physician addressed obesity somehow by recording an observation of weight problems in free text in EHR
OBESITY DIAGNOSIS BY SCHOOL PHYSICIAN	–	Binary variables: Actualised / Not actualised (at first grade / at fifth grade / at least once after the child had been affected by obesity for the first time during primary school)	Binary variable: Actualised / Not actualised (at some point after the child had been affected by overweight for the first time during primary school)	–	School physician had entered ICD-10 diagnosis E66 in EHR
SCHOOL NURSE ADDRESSED OBESITY SOMEHOW IN EHR	–	Binary variable: Actualised / Not actualised (at least once after the child had been affected by obesity for the first time during primary school)	–	–	School nurse addressed obesity somehow by recording an observation of weight problems in free text in EHR

OPTIMAL INTERVENTION	–	–	Binary variable: Actualised / Not actualised (after the child had been affected by overweight or obesity for the first time during primary school)	–	School nurse entered an observation of overweight or obesity into EHR, a school physician met the child for this reason or in course of a routine health check, a treatment plan was made together with parents and the next overweight-related appointment was in the plans. A recorded positive change in health habits or a concrete nutrition or exercise plan was also required. If a child attended the family centred group intervention or visited a paediatrician due to obesity in outpatient clinic, he/she was also deemed to have received *Optimal Intervention*

5 RESULTS

5.1 Characteristics of the Study population

Of the 508 children in studies III and IV, the median age was 7.2 years at the beginning of their follow-up (from 5.9-year-old to 12.3-year-old) and 12.6 years at the end (from 8.9-year-old to 14.9-year-old). The median total follow-up time was 5.4 years, varying between 1.4 and 7.2 years. For all the 573 children the median age at the beginning and at the end of their follow-up were likewise 7.2 and 12.6 years, respectively.

Pubertal development could be defined for most girls yet was unidentifiable from EHR entries for almost a fifth of the boys. Half of the girls were deemed *average* in pubertal development (M2 or M3 at grade 5 or menarche between health checks at grade 5 and 6). Of the boys, 30% had entered puberty by the 5th grade health check.

5.1.1 Psychosocial characteristics

Table 5:1 shows psychosocial characteristics for the 573 children. These data were used for sub-studies carried out after Study I. Characteristics are presented, separately for girls and boys, for the groups of 573 and 508 children.

For 23% of the study sample, at least one parent was a non-native Finnish or Swedish speaker. Over primary school, a third of children experienced bullying, 14% family crises and 18% required special help in studies. Over 80% of the children attended regular guided sport activities at some point. Children lived as often in families with married or cohabiting parents as in families with divorced or single parents (Table 5:1). Of the 573 children, a smaller proportion of girls had had special needs in studying, as compared to boys (14% vs. 21%, p=0.022) (Table 5:1). For the other variables in Table 5:1, the shares for girls and boys were close to each other and none of the variables were statistically significantly related to gender.

Table 5:1 *Psychosocial characteristics of the 573 primary school aged children affected by overweight or obesity by the weight-for-height references* (Sorva et al. 1984) *and the 508 children affected at least by overweight additionally by the Finnish BMI-for age references (508 children)* (Saari et al. 2011)

	573						508					
	Girls		Boys		Total		Girls		Boys		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
N	273	47.6	300	52.4	573	100.0	225	44.3	283	55.7	508	100.0
Parent(s) non-native for Finnish or Swedish	66	24.2	66	22.0	132	23.0	54	24.0	61	21.6	115	22.6
Family crisis [a]	37	13.6	44	14.7	81	14.1	31	13.8	40	14.1	71	14.0
Special needs in studying*[b]	38	13.9	64	21.3	102	17.8	29	12.9	61	21.6	90	17.7
Experiences in being bullied	88	32.2	111	37.0	199	34.7	75	33.3	107	37.8	182	35.8
Contact to psychiatric care	22	8.1	27	9.0	49	8.6	20	8.9	26	9.2	46	9.1
Specialised mental or social care [c]	70	25.6	94	31.3	164	28.6	59	26.2	89	31.4	148	29.1
Involvement in regular guided sport activity	233	85.3	257	85.7	490	85.5	190	84.4	249	88.0	439	86.4
Family structure												
Married or cohabiting parents	116	42.5	119	39.7	235	41.0	88	39.1	113	39.9	201	39.6
Divorced or single parents	103	37.7	130	43.3	233	40.7	92	40.9	122	43.1	214	42.1
Family structure not known	54	19.8	51	17.0	105	18.3	45	20.0	48	17.0	93	18.3

*[a] Any of the following situations mentioned at least once in primary school health checks: domestic violence, contacts to child protection services, mental health problems or drug or alcohol abuse of parents, legal disputes over child custody, sexual harassment of a child or death of a parent or sibling; [b] Any of the following mentioned at least once in primary school health checks: various forms of special education (performed in regular classes, special education classes or schools for special education), delayed starting of school, repeating a class or preparatory instruction classes for immigrants; [c] Specialised mental, neuropsychiatric or social care during primary school offered by school services, primary health care services or outpatient clinics; *The gender and the Special needs in studying variables were associated, Fisher's Exact Test p=0.022/0.014.*

5.1.2 Weight category before school age

Of the 1852 children, 1031 (56%) had always, before primary school when from 1 to 6 years of age, had normal-weight, 375 (20%) overweight at least once and 157 (8%) obese at least once, as examined per the national weight-for-height references. Growth measurements from child health clinics for 289 children between ages of 1 and 6 were either unavailable or insufficient in quantity (Table 5:2).

Table 5:2 *Highest weight category over primary school (1st to 6th grade) compared with highest weight category at 1-6 years of age in child health clinics (weight-for-height reference)*

	Weight status over primary school							
Weight status in child health clinic	Normal weight [b] n (%)		Overweight [c] n (%)		Obesity [c] n (%)		Total n (%)	
N	1278		402		172		1852	
Not enough measurements [a]	215	(16.8)	57	(14.2)	17	(9.9)	289	(15.6)
Normal weight [b]	900	(70.4)	114	(28.4)	17	(9.9)	1031	(55.7)
Overweight [c]	150	(11.7)	182	(45.3)	43	(25.0)	375	(20.2)
Obesity [c]	13	(1.0)	49	(12.2)	95	(55.2)	157	(8.5)

[a] *Under four measurements in child health clinic and no overweight or obesity*
[b] *Four or more measurements during six child health clinic years/six school grades and no overweight or obesity*
[c] *At least one overweight /obesity measurement according to weight-for-height reference*

5.1.3 Comparison of the weight category classifications according to weight-for-height, IOTF and BMI SDS references

Of the cohort of 2000 children including 1852 children with their weight category determined, 573 (31%) were classified as having overweight and 172 (9%) having obesity at some point during primary school, as determined by the weight-for-height reference. For girls, the corresponding percentages were 30% and 8% and for boys 32% and 11%. Weight-for-height and BMI SDS references used in the analyses and the IOTF reference used for comparison classified children somewhat differently, differences varying between gender and age. For the study sample of 573 children the proportions of children in *Ever Overweight* and *Ever Obese* classes were close to each other by the three references, yet differences became apparent when girls and boys were studied separately (Figure 5:1).

Compared with weight-for-height and IOTF references, BMI SDS reference seemed to classify girls less often into obesity class (Figure 5:1). The deviation between weight-for-height and BMI SDS references seemed to increase with age (Figure 5:2). Although at every school grade IOTF reference seemed to classify girls more often to overweight class than the other two references, the proportions of overweight girls were close to each other in all three classifications. Therefore, by BMI SDS classification more girls seemed to be recognized as normal weight, in total and at different school grades, as compared to the other references.

For boys, the difference was opposite (Figure 5:3); BMI SDS classified boys more often as obese and less often as normal weight compared to the two other references. This was pronounced in early school grades when comparing with weight-for-height reference. At 5th and 6th grades the classifications gave similar results.

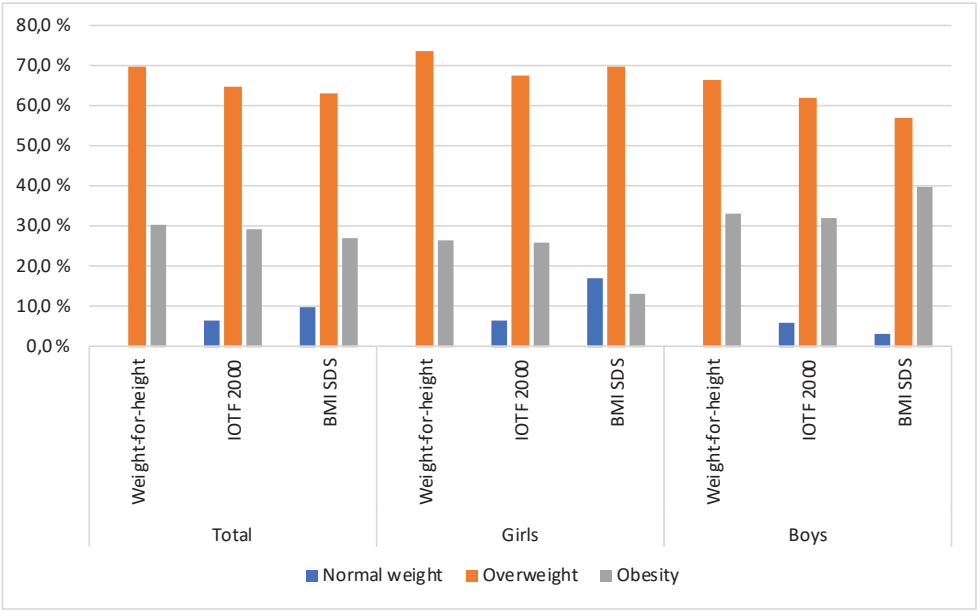


Figure 5:1 *Weight classification of the 573 children (273 girls and 300 boys) by weight-for-height* (Sorva et al. 1984), *by IOTF* (Cole et al. 2000) *and by Finnish BMI-for-age (BMI SDS)* (Saari et al. 2011) *references. Percentages of normal weight, overweight and obesity according to highest classification during primary school years*

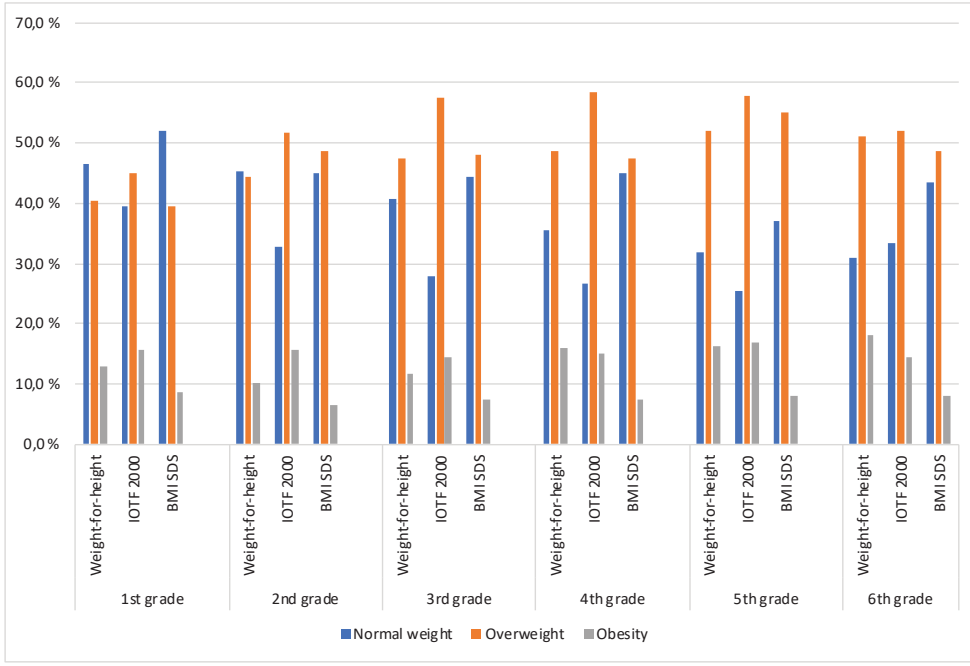


Figure 5:2 *Weight classification of the 273 girls affected by overweight during primary school (by weight-for-height reference) at six primary school grades. Percentages of normal weight, overweight and obesity among children measured at each grade (n varied from 236 to 265) by weight-for-height* (Sorva et al. 1984)*, by IOTF* (Cole et al. 2000) *and by Finnish BMI-for-age references (BMI SDS)* (Saari et al. 2011)

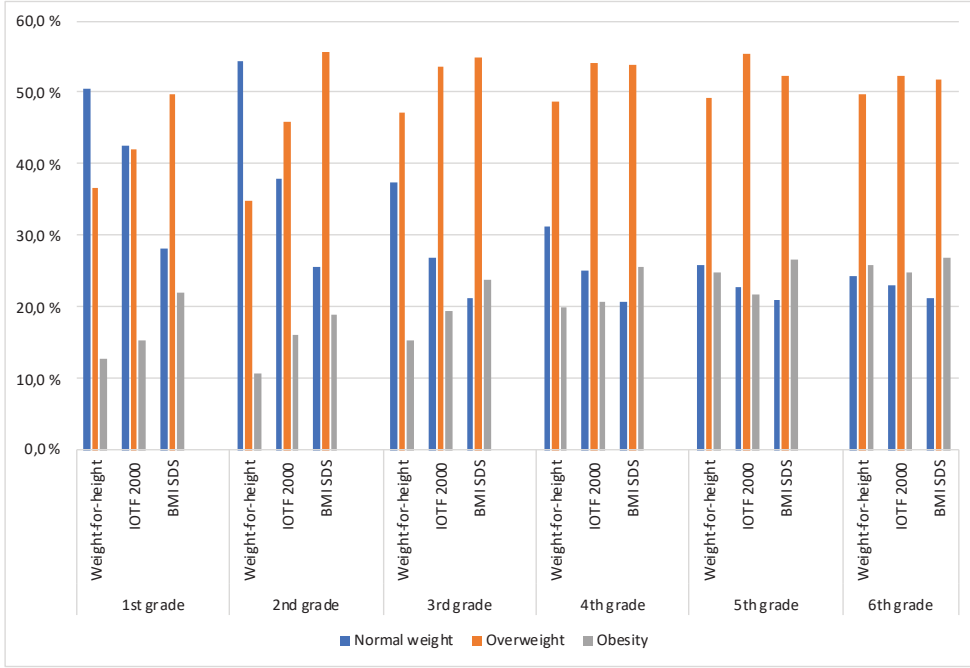


Figure 5:3 *Weight classification of the 300 boys affected by overweight during primary school (by weight-for-height reference) at six primary school grades. Percentages of normal weight, overweight and obesity among children measured at each grade (n varied from 255 to 285) by weight-for-height* (Sorva et al. 1984)*, by IOTF* (Cole et al. 2000) *and by Finnish BMI-for-age references* (Saari et al. 2011)

5.2 Development of overweight and obesity during primary school (Study I, III, IV)

5.2.1 Continuity of earlier weight categories into primary school (Study I)

Of the 1278 children with normal weight during primary school years, 70% had always been measured normal weight at child health clinics before school age (from 1 to 6 years of age). Vice versa, of the 1031 children with normal weight before school age, most (87%) remained normal weight throughout primary school (Table 5:2).

Of the 172 children belonging to *Ever-Obese* class, 80% had been affected either by obesity (55%) or overweight (25%) at least once before school age and only 10% had always been normal weight before school age (Table 5:2).

5.2.2 Continuity of weight categories during primary school (Study I)

The prevalence of obesity, as determined by weight-for-height reference, increased over primary school years. After reaching obesity, it remained stable. At 1st grade, 67 (12%) of the 574 *Ever Overweight* or *Ever Obese* children were classified as having obesity by weight-for-height classification and at 6th grade the count increased to 118 (21%). Of the 172 children in *Ever Obese* class (by weight-for-height reference), 56% had overweight or obesity at all the six school grades and only 11% at less than four grades. Figure 5:4 shows the count of grades separately for girls and boys.

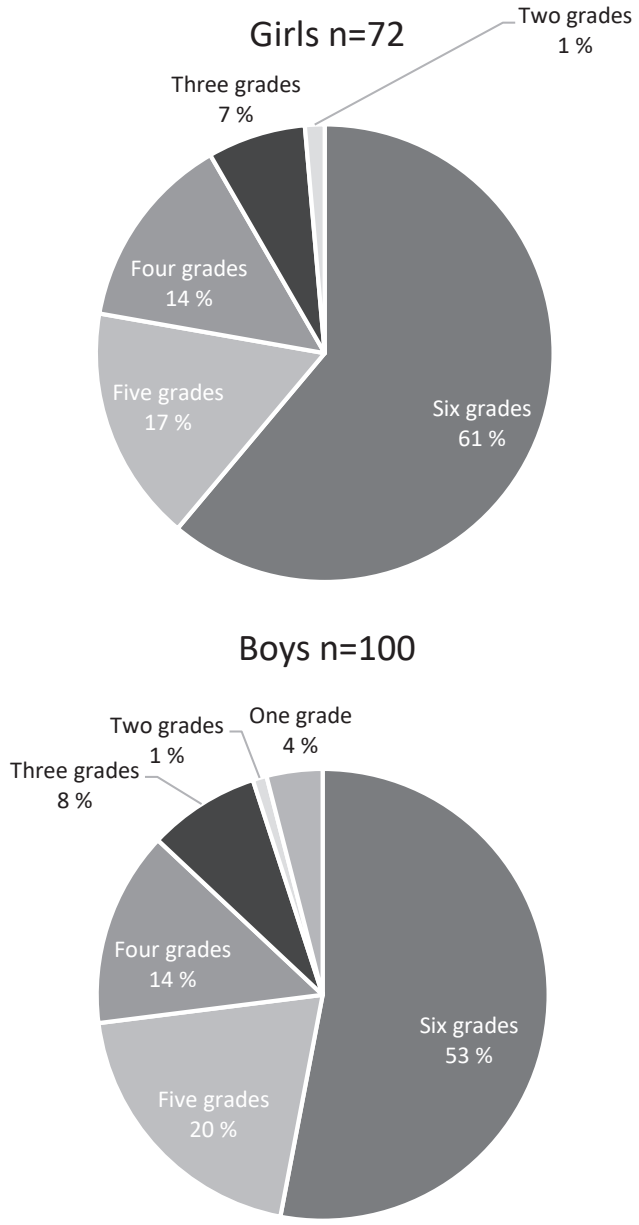


Figure 5:4 *Count of grades at which girls (n=72) and boys (n=100) with obesity at some point during primary school (by weight-for-height classification) were affected either by overweight or obesity*

5.2.3 Trajectories of overweight and obesity (Study III)

By BMI SDS reference, as comparing to weight-for-height reference, the increase in prevalence of obesity during primary school was less obvious and mostly seen for boys (Figures 5:2 and 5:3). However, analysis of BMI SDS means at each target age showed a clear increase, especially for boys, in the BMI SDS means through 7 to 13 years of age (Figure 5:5).

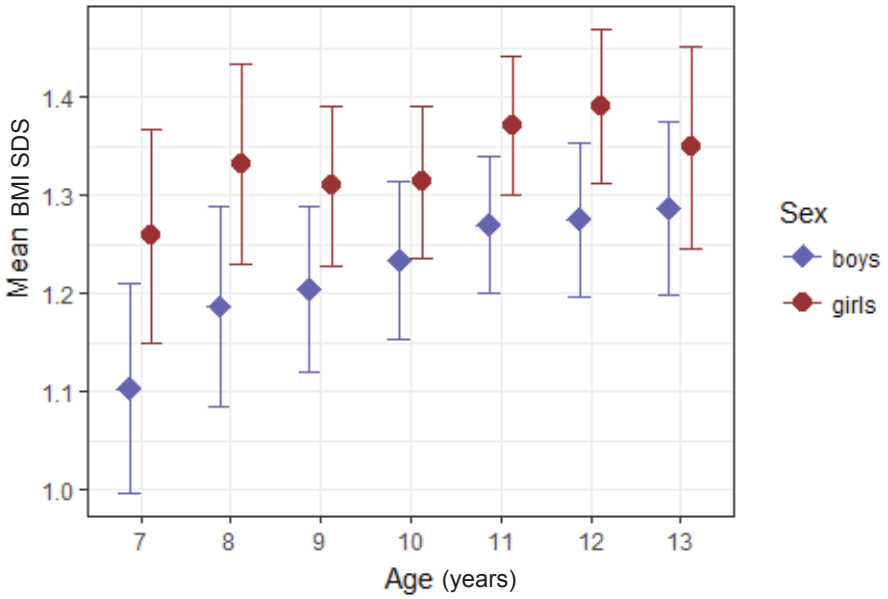


Figure 5:5 *Weight development of 508 children with overweight (Study III, 225 girls and 283 boys) presenting means and 95% confidence intervals of the nearest BMI SDS measurements around every target age (-0,50 to +0,49 years) from 7 to 13 years of age. BMI SDS measurements for boys and girls between ages 7 and 13 were normally distributed and therefore the means and 95% CI are shown. The n varies as not all children had measurements every year*

Nine sex-specific overweight trajectories of BMI SDS were identified by using latent class mixed model; five for girls and four for boys (Study III). The latent classes received names according to the shapes of the trajectories. Both girls and boys had latent classes of *Stable Overweight*, *Increasing to Overweight* and *Transitory Overweight*. The boys with *Stable Obesity* formed a one distinct trajectory

and girls had two distinct classes; *Fluctuating Obesity* and *Decreasing Obesity*. The trajectories are illustrated in Figure 5:6.

Stable Overweight classes were the most populous classes covering 50% (n=113) of the girls and 37% (n=104) of the boys. Towards the end of primary school, the *Stable Overweight* trajectory of girls dipped yet for boys it began to rise. Of the girls 29% (n=65) and of the boys 17% (n=49) were continuously gaining weight in *Increasing to Overweight* trajectories, which rose to overweight area close to the age of 10. *Transitory Overweight* class for girls was smaller (n=20) and the trajectory steeper than the respective for boys (n=99). The obesity classes *Fluctuating Obesity* (n=14) and *Decreasing Obesity* (n=13) included 12% of the girls and the *Stable Obesity* class 11% (n=31) of the boys.

The trajectories of obesity latent classes were relatively stable. Notably this applied to the trajectory of *Stable Obesity* class for boys, which stayed at obesity area throughout the primary school years. Also, the trajectories of *Decreasing Obesity* and *Fluctuating Obesity* for girls were in obesity or in overweight area all the six years. Weight development of children in these latent classes diverged, as 95% CIs of the two BMI SDS trajectories overlapped in the beginning of primary school yet differed at the end (Figure 5:6).

The five trajectories for girls commencing form normal weight, overweight and obesity were closest to each other at the age of 10 and for boys at around the age of 11. At that age, most trajectories were in overweight area, the only exception being *Stable Obesity* trajectory for boys. After this moment of intersection, the trajectories dispersed and only some continued into obesity. The age from 10 to 11 years seems to be decisive for later obesity development.

The timing of pubertal development was not associated with identified latent classes; neither for girls nor for boys. For girls, in Study III, pubertal development was evaluated and classified as early, average, late or not known (p=0.289) and by menarche / no menarche by 5th grade (p=0.336, median age 11.5) as well as by 6th grade (p=0.324, median age 12.6). Similarly, for boys, pubertal development, classified into early, started, not started or not recorded by 5th grade health check, was unrelated to the latent classes (p=0.291).

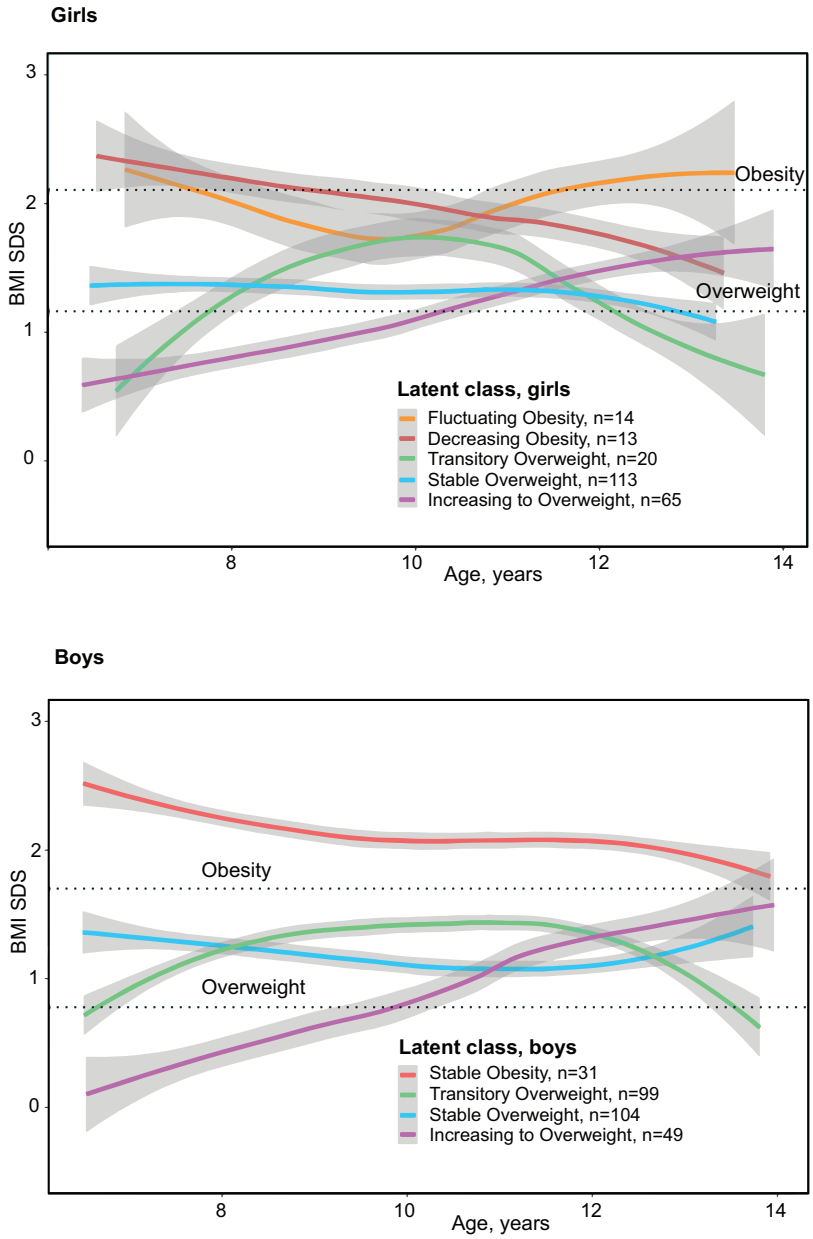


Figure 5:6 *BMI SDS trajectories with 95% CIs for girls and boys of the 225 girls and 283 boys with overweight or obesity during primary school between ages of 6 and 14. Cut-offs for overweight (girls 1.16, boys 0.78) and obesity (girls 2.11, boys 1.70) according to the Finnish BMI-for-age references (Saari et al. 2011). BMI SDS, body mass index standard deviation score. Figure reprinted with the permission obtained from the Acta Paediatrica (Publication III)*

5.2.4 Probability of transitioning between weight categories (Study IV)

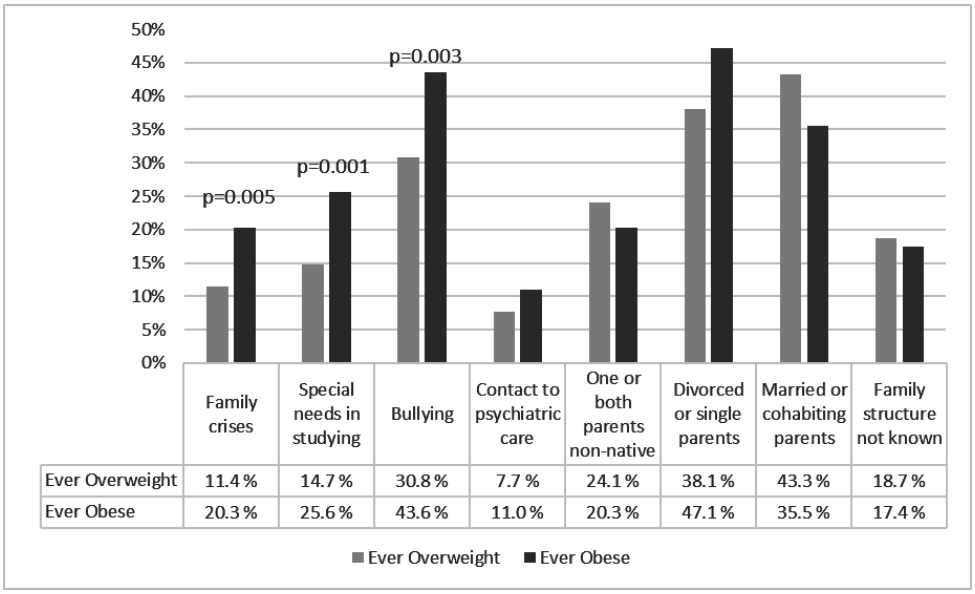
For the 507 children having had overweight at some point in time, 3116 consecutive measurements were observed. Analyses of the measurements showed that 77% of the pairs of measurements were non-transitioning and almost half were in the overweight category, both for girls and boys. Children transitioned from a weight category to another altogether 719 times during the six primary school years. The highest 1-year probabilities of transitioning were detected for girls with overweigh for remaining in overweight category (76%) and for boys with obesity for staying in obesity category (80%). The probability of remission from overweight to normal weight over the next year was smaller than the probability of developing overweight or of staying in overweight category. Contrarywise, especially girls transitioned from obesity to overweight several times more probably than developed obesity, although staying in obesity remained the most likely scenario. For a single visit in a category, girls were estimated to spend the longest (2.8 years) in overweight category and boys in obesity category (4.1 years).

Both girls and boys initially having overweight were estimated to spend around four of the six primary school years in overweight category. For girls initially with obesity, the estimated total times spent in overweight and obesity categories were almost equal. Boys initially affected by obesity were estimated to spend a longer time (3.6 years) in obesity category than in overweight category.

5.3 Psychosocial characteristics associated with overweight and obesity (Study I, (III), IV)

Of the psychosocial characteristics studied, some family- and school related characteristics were more common during primary school among children in *Ever Obese* class compared with children in *Ever Overweight* class (Figure 5:7) (Study I). Some characteristics were spread unevenly between the latent classes identified for girls and boys in Study III (these were not reported in the published paper as the study concentrated on reporting the differences in interventions offered for children of different latent classes). Additionally, several psychosocial characteristics were as-

sociated with transition rates between weight categories of normal weight, overweight and obesity (Study IV); family-related especially for girls and school-related for boys.



	Family crises	Special needs in studying	Bullying	Contact to psychiatric care	One or both parents non-native	Divorced or single parents	Married or cohabiting parents	Family structure not known
Ever Overweight	11.4 %	14.7 %	30.8 %	7.7 %	24.1 %	38.1 %	43.3 %	18.7 %
Ever Obese	20.3 %	25.6 %	43.6 %	11.0 %	20.3 %	47.1 %	35.5 %	17.4 %

Figure 5:7 *Psychosocial characteristics of Ever Overweight (n=402) and Ever Obese (n=172) children (Study I)*

5.3.1 Family structure

Of the family- and school-related characteristics studied, family structure was unrelated to *Ever Overweight* or *Ever Obese* classifications (Study I) (Figure 5:7). However, for girls, transitions towards obesity were related to living with divorced or single parents (Study IV). Compared with boys from families with married or cohabiting parents, boys with divorced or single parents developed obesity at a lower rate yet transitioned at higher rates from normal weight to overweight and vice versa (Study IV).

5.3.2 Native language of parents

The circumstance of one or both parents being non-native for Finnish or Swedish was unrelated to *Ever Overweight* or *Ever Obese* groups (Study I) (Figure RPS). Yet, overweight latent classes for boys were associated with the native language variable (p=0.001) (Study III). *Stable Overweight* class exhibited the lowest share and *Stable Obesity* the highest share of boys of non-native families (Table 5:3). However, for girls, the persistence of obesity was related to living in a non-native family.

5.3.3 Bullying and crises

A history of being bullied and having had family crises during primary school were more common among children in *Ever Obese* class than among children in *Ever Overweight* class (Figure 5:7) (Study I). Being bullied or family crises were unrelated to distinct latent classes of weight development of girls or boys (Table 5:3). Instead, primary school boys having experienced bullying or crises transitioned at a higher rate from overweight to obesity and at a lower rate from overweight to normal weight (Study IV).

5.3.4 Special needs in studying

Special needs in studying during primary school were, similarly, more common among children in *Ever Obese* than in *Ever Overweight* class (Figure 5:7) (Study I). Special study needs were also associated with latent classes of boys (p=0.001). *Stable Overweight* class exhibited the lowest share, and *Stable obesity* and *Increasing to Overweight* the highest shares of children having special study needs (Table 5:3). (Study IV). Boys with special study needs transitioned from overweight to obesity as well as from overweight to normal weight at a higher rate than boys without such study needs (Study IV).

Table 5:3 *Psychosocial characteristics in distinct latent classes of overweight trajectories of primary school girls (n=225) and boys (n=283)*

	Overall		Fluctuating Obesity		Decreasing Obesity		Stable Overweight		Transitory Overweight		Increasing to Overweight		P
Girls	n = 225 (100.0%)		n = 14 (6.2%)		n = 13 (5.8%)		n = 113 (50.2%)		n = 20 (8.9%)		n = 65 (28.9%)		
Psychosocial characteristics, n (%)													
Non-native family [1]	54	(24.0)	2	(14.3)	3	(23.1)	23	(20.4)	7	(35.0)	19	(29.2)	0.424[b]
Family crises [2]	31	(13.8)	3	(21.4)	3	(23.1)	13	(11.5)	2	(10.0)	10	(15.4)	0.555[b]
Special needs in studying [3]	29	(12.9)	2	(14.3)	5	(38.5)	11	(9.7)	1	(5.0)	10	(15.4)	0.054[b]
Bullying	75	(33.3)	7	(50.0)	7	(53.8)	31	(27.4)	6	(30.0)	24	(36.9)	0.167[a]

	Overall		Stable Obesity		Stable Overweight		Transitory Overweight		Increasing to Overweight		P
Boys	n = 283 (100.0%)		n = 31 (11.0%)		n = 104 (36.7%)		n = 99 (35.0%)		n = 49 (17.3%)		
Psychosocial characteristics, n (%)											
Non-native family [1]	61	(21.6)	11	(35.5)	10	(9.6)	29	(29.3)	11	(22.4)	0.001[a]
Family crises [2]	40	(14.1)	4	(12.9)	11	(10.6)	15	(15.2)	10	(20.4)	0.424[a]
Special needs in studying [3]	61	(21.6)	11	(35.5)	12	(11.5)	20	(20.2)	18	(36.7)	0.001[a]
Bullying	107	(37.8)	17	(54.8)	40	(38.5)	36	(36.4)	14	(28.6)	0.127[a]

[1] One or both parents non-native for Finnish or Swedish; [2] Any of the following situations mentioned at least once in primary school health checks: domestic violence, contacts to child protection services, mental health problems or drug or alcohol abuse of parents, legal disputes over child custody, sexual harassment of a child or death of a parent or sibling; [3] Any of the following mentioned at least once in primary school health checks: various forms of special education (performed in regular classes, special education classes or schools for special education), delayed starting of school, repeating a class or preparatory instruction classes for immigrants. Testing for associations between psychosocial characteristics and overweight trajectories; [a]Pearson's chi-square test; [b]Fisher's exact test

5.4 Overweight and obesity screening in school health care

The ability of school health care professionals to detect overweight was analysed in Study II and III. School nurses were adept at catching obesity and recorded it into EHR at least once for virtually all children in *Ever Obese class*. School physicians mentioned weight issues for all 5th graders and most 1st graders (79%) with obesity (Figure 5:8). Yet, physicians were timid to set obesity diagnoses and only 27% of 5th graders with obesity, 23% of 1st graders with obesity (Figure RS) and 29% of the 157 children who became obese before 5th grade, received an obesity diagnosis. Diagnoses increased with weight status; school physicians set a diagnosis for 63% of the 43 children with severe obesity (>160% from median weight-for-height) (Study II). Of the children in the latent classes of obesity, *Decreasing Obesity* and *Fluctuating Obesity* for girls and *Stable Obesity* for boys, 31%, 57% and 39%, respectively, received an obesity diagnosis made by a school physician (Study III).

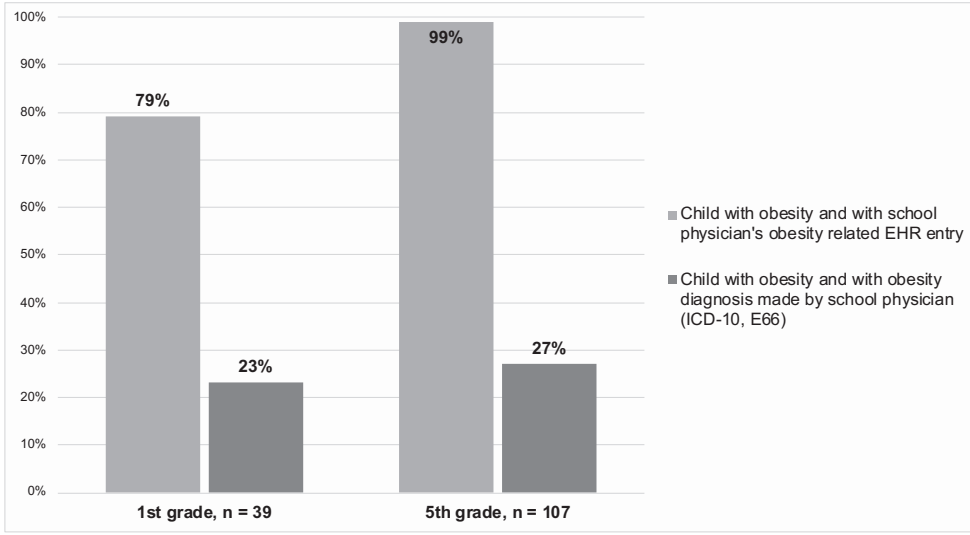


Figure 5:8 *Proportion of the children who received an obesity diagnosis or had an obesity-related EHR entry made by school physician. Percentages of the 39 and 107 children met by school physician and affected by obesity at first or fifth grade (by weight-for-height classification). EHR = Electronic Health Record (Study II)*

5.5 Overweight-related interventions offered in school health care (Study II, III)

The ability and manners of school health care professionals for offering interventions were analysed in three study samples in Studies II and III. The records of actualised school health checks and interventions offered to the 172 children in *Ever Obese* class were analysed. In Study II, the interventions offered after measuring a child obese for the first time were analysed for the 157 children affected by obesity before 6th grade (Figure 5:8). In Study III, associations between overweight trajectories and actualised school health care interventions were examined, separately for girls and for boys.

5.5.1 School health checks

Annual school health checks by school nurses during primary school actualised well. Of the 172 *Ever Obese* class children, school nurses met, for an annual health check, 86% of them at five or more school grades (Study II). All 508 children (with overweight or obesity by both classifications and included in the latent class analysis of Study III) met a school nurse at least once after being affected by overweight.

Naturally, school physicians met children less often. At 5th grade multidisciplinary health checks school physicians reached most (93%) of *Ever Obese* children and almost all (n=107, 95%) of the 113 children with obesity at that grade (Study II). On the contrary, at 1st grade, only 53% of *Ever Obese* children met a school physician at a health check. Likewise, of the 67 children with obesity at 1st grade, school physicians reached only 39 (58%) of them. Of the 508 children in the latent class analysis, 46% of girls and 50% of boys met a school physician at 1st grade health checks (Study III). Latent classes were unrelated to the actualisation of legislated 1st and 5th grade health checks, performed by school physicians.

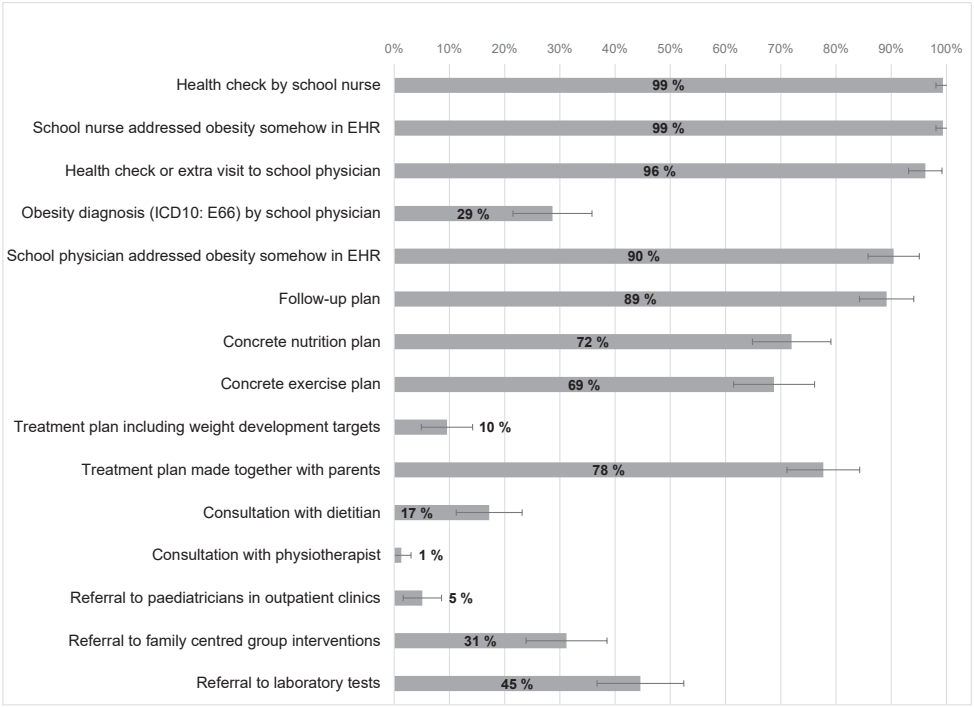


Figure 5:9 *Percentage of children who were offered different interventions for obesity at least once during primary school by school nurses or physicians after the child had been measured obese for the first time (95% confidence interval). Of the 172 'ever-obese' children (weight-for-height classification), the 157 who became obese before sixth grade were included. EHR, Electronic Health Record*

5.5.2 Overweight-related extra visits

School nurses met 72% of the 172 *Ever Obese* children at overweight-related extra visits. Of the *Ever Obese* children, 24% had an extra visit to a school nurse, 16% had two and 23% had from 3 to 5 extra visits. Also, children were unaccompanied at almost all (94%) of the overweight-related extra visits (Study II).

Of the 172 *Ever Obese* children, 77% had done without overweight-related extra visits to school physicians over their primary school years (Study II). Additionally, less than 10% of the 508 children included in the latent class study had met a school physician for an extra health check or for overweight-related reasons between their 1st and 5th grades (Study III). The proportion was somewhat higher for

the latent classes of obesity for girls (22%) and for boys (32%). Parents accompanied their children in half of the overweight-related extra visits to school physicians (Study II).

In contrast to legislated health checks, extra checks were statistically significantly related to latent classes of both girls ($p=0.004$) and boys ($p<0.001$) (Study III). Girls in *Decreasing Obesity* (31%) and boys in *Stable Obesity* (32%) class were most often involved in the extra checks.

5.5.3 Overweight-related interventions

At first grade, referrals and consultations were seldom used. Nevertheless, the attendance of parents at multidisciplinary health checks of grades 1 and 5 led to more treatment plans having been made together with parents than at other health checks (Study II). Recorded interventions were targeted more often at children of the latent classes of *Stable, Fluctuating* and *Decreasing Obesity* than of other classes (Study III). These interventions are elaborated in more detail in the following paragraphs.

5.5.3.1 Treatment plans

A plan for a subsequent overweight-related appointment was the most common element in treatment plans. It was set up at least once for 89% of the 157 children with obesity (Study II) (Figure 5:9). A plan for a next appointment was made for 65% of the 225 girls and for 59% of the 283 boys included in latent class analyses, for essentially all (93%) girls of obesity trajectories and for every boy in *Stable Obesity* trajectory (Study III).

The interventions offered varied between school grades. 1st graders seemed to get the fewest interventions overall, but treatment plans were most often devised together with parents at 1st and 5th grades, for 66% and 63% of the 172 *Ever Obese* children, respectively. For 78% of the 157 children with obesity by 5th grade, at least one treatment plan was made jointly with parents (Study II) (Figure 5:9).

Concrete exercise or nutrition plans were made three or more times during primary school for 20% (exercise) and 25% (nutrition) of the 172 ever-obese children

(Study II). Still, over primary school, 26% of the children never received an exercise plan and 21% a nutrition plan. Of the 508 children with overweight (by both the weight-for-height and BMI-for-age references), half of the boys and half of the girls had had at least one exercise or nutrition plan during primary school. Exercise and nutrition plans were related to latent classes of boys and were most frequently found in *Stable Obesity* class (Study III).

5.5.3.2 Participation in family centred group interventions

Family centred group interventions for obesity management were offered at least once to 31% of the 172 ever-obese children. At every grade from 2nd to 5th, children were offered family centred group intervention as often, and more often than at 1st or 6th grades. Actual attendance in interventions was lower (Study II). Of the 225 girls and 283 boys in latent classes, 13 girls (5.8%) and 14 boys (4.9%) attended the interventions and this attendance was related to latent classes ($p=0.020$ (girls), $p<0.001$ (boys)). The share of children taking part in the group interventions was greatest in latent classes of *Decreasing Obesity* (23%) and *Stable Obesity* (26%) (Study III).

5.5.3.3 Visits to paediatricians in outpatient clinics

Five percent of the 172 ever-obese children (by weight-for-height) were referred to outpatient clinic paediatricians due to their weight (Study II). Visits to paediatricians were expectedly statistically significantly related to latent classes; girls in *Decreasing Obesity* (31%) and boys in *Stable Obesity* (10%) having the greatest shares (Study III).

5.5.3.4 Optimal intervention

Of the girls, 40% and of the boys, 34% had received Optimal Intervention. Optimal Intervention and latent classes were found to be statistically significantly related ($p<0.001$) (Study III). Children in the latent classes of obesity received Optimal Intervention more often than children gaining weight or with stable overweight. The percentages for children getting Optimal Intervention in *Fluctuating Obesity* (79%) and *Decreasing Obesity* (85%) classes for girls and for *Stable Obesity* (77%) class for boys were all close to each other.

5.5.3.5 Consultations with dietitians and physiotherapists

Consultations with dietitians were seldom organised for children with overweight or obesity. Of the 172 *Ever Obese* children, just 27 (16%) visited a dietitian during primary school (Study II). Almost as often, consultations were offered yet fell short of being realised. Among the latent classes, *Fluctuating Obesity* class for girls (29%) and *Stable Obesity* for boys (13%) had the highest share of children having had consultations with dietitians (Study III). The association between latent classes and visits to dietitians was statistically significant (p= 0.021).

Overweight or obesity was hardly ever the primary reason for a consultation to a physiotherapist. Only two out of the 157 ever-obese children affected by obesity by 5th grade had visited a physiotherapist primarily due to overweight (Study II). Of the 508 children overweight both by weight-for-height and BMI SDS references, 11% had visited a physiotherapist for other reasons. The shares of children having been offered consultations with physiotherapists were not related to latent classes (Study III).

5.5.3.6 Weight development targets

Weight development targets were rarely set. Targets were mentioned in EHR for just 10% of the 172 *Ever Obese* children (Study II). For boys, weight development targets were related to latent classes. *Stable Obesity* class had the greatest proportion, one fourth, of boys having had weight targets recorded in EHR.

6 DISCUSSION

6.1 Summary of the main findings

This thesis explored the overweight development of children during primary school years and its relation to interventions offered to those affected by overweight or obesity. The overall objective was to offer novel material both to those making decisions on school health care policies and to school health care professionals. In order to improve obesity prevention and treatment processes in school health care, knowledge on current intervention practices and typical overweight development patterns of children is needed.

The results showed that obesity of primary school children had often developed already before school age and it seemed to continue throughout primary school. Likewise, most children who had stayed in normal weight category before school age had normal weight also over primary school. Girls and boys affected by overweight in the beginning of primary school and boys with obesity were estimated to stay most of the primary school years at that initial weight category. For all children with overweight or obesity, over a one-year period, staying at overweight or obesity was the most probable scenario. Yet, girls with overweight transitioned to normal weight five times more probably than moved to obesity, for boys both paths were equally probable. The probability of remission from overweight to normal weight was lower than the probability of moving from normal weight to overweight. On the contrary, the probability of remission from obesity to overweight was many times higher than the probability of developing obesity, especially for girls.

Distinct, gender-specific overweight trajectories were identified, five for girls and four for boys, and they showed the age between 10 to 11 to be decisive for later weight development. All, except the Stable Obesity trajectory for boys, were in overweight area at that age. It is notable that, close to the age of 10, the *Increasing to Overweight* trajectories both for girls and for boys rose to the overweight area and continued from there towards obesity.

Both girls and boys affected by obesity had had more often experiences of family crises and being bullied, as compared to children with overweight. The same

applied for special needs in studying. Transition rates between weight categories were also associated with gender, age and family- and school-related characteristics. Transition rates to obesity were higher for girls living with divorced or single parents than for those in nuclear families. Also, obesity seemed to be more persistent for girls living in non-native families than for girls living in native families. Among boys, transitions to obesity were associated with experiences of crises and being bullied and seemed to be associated as well with a need for special help in studies.

School nurses and physicians identified overweight and obesity effectively, although physicians seldom set obesity diagnoses. Interventions of school health care comprised mainly of planning for next appointments, less of long-term treatment plans. Interventions offered actualised less among children in trajectories of gaining weight, more so amid children with obesity. Co-operation with families was less frequent than in the targets of school health care. Children mostly attended weight-related appointments with school nurses alone, and parents were present at just a half of comparable visits to school physician.

This thesis implicates that distinct groups of children with increased probability for unhealthy weight development can be identified by information entered in primary health care EHRs. Such groups are, for example, boys having had experiences of crises or bullying and girls of non-nuclear or non-native families. Exploiting knowledge on earlier weight development and parent-, family- and school-related factors of children offers a potential means for directing school health care interventions wisely.

6.2 Interpretation of the results

6.2.1 Development of overweight and obesity during primary school

This study observed development and continuity of overweight and obesity over primary school grades by studying the prevalence and incidence of overweight and obesity at the time. Additionally, by adopting latent class mixed models to discover distinct overweight trajectories and applying multistate models to estimate prob-

abilities of transitioning between weight categories the study acquired novel gender-specific knowledge on typical weight development over primary school years.

The overall findings of the continuity of overweight and the discovery that children with obesity often developed obesity already before school age were congruent with earlier knowledge pointing that overweight and obesity start early in childhood (Lagström et al. 2008, Cunningham et al. 2014, Tran et al. 2016, Woo Baidal et al. 2016, Geserick et al. 2018). According to the results of this thesis, most children having overweight during primary school were overweight already before school age. Only 10% of *Ever Obese* children had been always at normal weight before school age, this being analogous with findings from cohorts in the United States and Australia (Cunningham et al. 2014, Wheaton et al. 2015). This thesis identified that girls and boys who initially had overweight and boys who had obesity were estimated to spend most of their primary school years at the same weight category. Another finding was that children with obesity still had obesity a year later much more probably than experiencing remission.

The percentages of girls and boys affected by overweight or obesity at some point during primary school (30%/8% and 32%/11%, respectively) were naturally higher in this study cohort than the Avohilmo register cross-sectional prevalence figures of 18% and 4% for 2-16-year-old girls and 27% and 8% for boys (Lasten ja nuorten ylipaino ja lihavuus 2019). In this study, mean BMI SDS and prevalence of overweight and obesity both increased over primary school, as also seen earlier (von Kries et al. 2012, Cunningham et al. 2014, Mäki et al. 2018, Moreira et al. 2019). The increase in prevalence over primary school years has been seen in Finland since 1990's (Vuorela et al. 2009, Vuorela et al. 2011). Depending on the cohort, the incidence of overweight and obesity along age has either been found to remain the same, increase or decrease (von Kries et al. 2012, Cunningham et al. 2014). However, low or reducing remission from obesity and overweight along age has been a constant finding (von Kries et al. 2012, von Kries et al. 2013, Wheaton et al. 2015, Moreira et al. 2019, Juonala et al. 2020) and it has been suggested to explain a major part of the increased prevalence.

Reduced remission has been clearly demonstrated among German children; for pre-schoolers remission rates from overweight and obesity were higher than incidence rates but at primary school age vice versa (von Kries et al. 2012). In this study, the 1-year probability of remission from obesity to overweight was higher than transitioning the opposite way. Older girls and boys, compared with younger children (girls ≥9.5 vs. <9.5, boys ≥10.5 vs. <10.5), transitioned from normal weight to overweight and girls from overweight to obesity more probably over the following year, yet age groups were not related to transition rates of remission.

In addition to discovering results congruent with earlier findings on high probabilities of staying at overweight or obesity categories (Tran et al. 2016, Moreira et al. 2019), the present study also noticed gender differences. Boys moved to the obesity category and stayed there more probably than girls. Girls transitioned more probably than boys from obesity to overweight and less probably from overweight to obesity over the next 12 months. Also, girls with overweight transitioned to normal weight over the next year five times more probably than moved to obesity. For boys, both transitions were equally probable. The results on boys were in line with an earlier study where girls and boys were analysed as one group (Moreira et al. 2019). According to the results of this thesis, over a single category visit, girls were estimated to stay the longest, almost 3 years, in overweight category and boys in obesity category (4 years). Similarly, for girls the highest 1-year probability was for staying in overweight category and for boys in obesity category.

Children can be divided into groups by the shapes of their weight development curves and thereby it is possible to acquire novel information on obesity development utilising the latent class method (Mattsson et al. 2019). The five trajectories identified in this study for girls and four for boys were in line with the 3 to 6 trajectories found per gender in earlier studies (Hejazi et al. 2009, Garden et al. 2012, Haga et al. 2012, Nummi et al. 2014, Brault et al. 2015, von Bonsdorff et al. 2015, Munthali et al. 2016). Note that children with normal weight were excluded from this study. It is possible that, by concentrating on children with overweight and obesity and having abundant weight measurement data, this study found a broader variety of overweight trajectories. In addition to commonly identified trajectories (stable high and accelerating) a *Transitory Overweight* trajectory was identified

both for boys and girls. This implies that a group of children exists that, regardless of accelerating weight development, returns to normal weight by the end of primary school. Additionally, two obesity trajectories were identified for girls; *Fluctuating Obesity* and *Decreasing Obesity.* Therefore, at least two typical scenarios can be seen for primary school girls with obesity. The more desirable one was the one that slowly but steadily declined towards normal weight.

Comparing weight status before and during primary school, it was seen that children at normal weight before entering school were fairly safe from obesity development, this being in line with earlier findings (Geserick et al. 2018). Similarly, girls and boys in the latent classes of *Stable Overweight* trajectories (50% of girls and 37% of boys), even though being overweight, seemed to be in a stable situation without obesity development. On the contrary, 17% of girls and 29% of boys belonged to *Increasing to Overweight* trajectories and therefore were at a steady ascending trend towards obesity. Most of the trajectories, whether from normal weight, overweight or obesity, were in the overweight area around the age of 10. However, only some of the trajectories continued into obesity. By adding other information to this weight development data, children with a risk of continuing to obesity might be detected earlier with suitable predictor models (Ziauddeen et al. 2018) and offered immediate interventions. Therefore, the age of around 10 can be interpreted as a turning point and a potential age for changing the direction of an individual child's weight development, especially if earlier prevention has not proved successful.

The prevention and treatment of obesity calls for identification of children with overweight or obesity who are prone to continue gaining weight. Also, we should spot children with normal weight whom may have an increased risk of obesity development later on. However, identifying those with a reduced risk, and therefore without need for intervention, should also be a target (Juonala et al. 2020). Limited health care resources could be saved for children with a need for interventions, rather than spending them on extra appointments for children with overweight who have no current health problems and are unlikely to develop obesity.

Weight development information offers a significant advantage over momentary weight data, while also other early-life determinants remain crucial for constructing prediction models (Ziauddeen et al. 2018, Juonala et al. 2020, Welten et al. 2020, Ziauddeen et al. 2020).

6.2.2 Factors associated with the overweight and obesity development

6.2.2.1 Family-related factors

Family structure has been shown to be related with childhood overweight (Schmeer 2012, Parikka et al. 2015, Duriancik and Goff 2019). In this thesis, the classification for family structure posed a challenge as the data was non-existent as independent EHR entries and therefore had to be gathered from free text entered over the whole six primary school years. Still, the finding of girls of divorced or single parent families transitioning at a higher rate to obesity was congruent with the results of children in nuclear families having a lower risk for overweight and obesity (Duriancik and Goff 2019).

According to Helsinki 2013 statistics, of all families with children, 68% of parents were in marriage or cohabiting. Of children, 74% lived with married or cohabiting parents (City of Helsinki Urban Facts 2013b); in this thesis the corresponding percentage was 58. The difference seems justifiable as the study sample included only children with overweight and, furthermore, some of the children classified as having divorced parents might in fact have been living in reconstituted families with two parents.

The native language of the family was an exceedingly difficult variable and also needed to be gathered mainly from free text. The variable was formed as language difficulties could affect the relationship and communication between school health personnel and families, and therefore also the offered treatment (Mäenpää et al. 2013, Rocque and Leanza 2015). Importantly, the native language variable enabled examining cultural and ethnic differences in weight development and treatment: cultural attitudes towards overweight could play a role in the whole (Fitzgibbon and Beech 2009).

Of the population of Helsinki in 2013, the native language of 12% was other than Finnish or Swedish and 21% of families with children aged under 18 years had at least one parent who was non-native for Finnish or Swedish (City of Helsinki Urban Facts 2013a). Of the study sample of this thesis, 23% of children had at least one non-native parent. Earlier studies indicate teenage girls of non-native families to be more often affected by overweight and obesity than their peers of Finnish or Swedish speaking families (Alitolppa-Niitamo et al. 2014, Mäki et al. 2019b). This thesis recognized equal proportions of girls of non-native and native families to have been affected by obesity over their primary school years. Still, girls of non-native families had a lower rate of transitioning from obesity to overweight. This could explain the finding that obesity prevalence remains higher among teenagers of non-native families.

Over primary school, 14% of the 507 children had experienced some type of crises. Severe incidents having occurred in the children's lives were included the crises variable, excluding ones already included in other study variables, such as bullying and divorce. Crises were more common among children in *Ever Obese* class than in *Ever Overweight*, likewise to family-level stressors in previous studies (Garasky et al. 2009, Parks et al. 2012). Similarly, perceived parental stress (Shankardass et al. 2014) has been previously associated with childhood weight status, as well as childhood maltreatment with adult obesity (Danese and Tan 2014). Furthermore, parental and offspring stress fits as a mediator between crises and obesity (Hemmingsson 2018). In this thesis EHR data was naturally unable to relay the stress level of parents or children, so it was indirectly examined by identifying adverse incidents in the children's and their families' lives. Likewise, most of the crises included in this study presumably had some effect on the whole family.

Although crises were unrelated to distinct latent classes of growth patterns in this study, the results could point to them inducing obesity development and reducing overweight remission for primary school boys. This would be due to the results from Study I and IV indicating that crises were more common among children with obesity and, among boys, associated with transition rates between weight categories.

There are other matters in life inducing stress on top of the ones collected for the variable of crises. The association of low SES and obesity may be mediated by stress, and similarly bullying and special needs in studying may induce stress. Therefore, bullying and special needs in studying being associated with obesity may be, at least in part, mediated by stress (Stavrou et al. 2017). Weight category transitions were observed to be associated equivalently with both crises and bullying. Therefore, family- and school-related factors such as crises, bullying, special needs in studying, family structure and non-native status of the family are potentially all connected to each other and to obesity by the distress they might induce. Figure 6:1 shows possible connections.

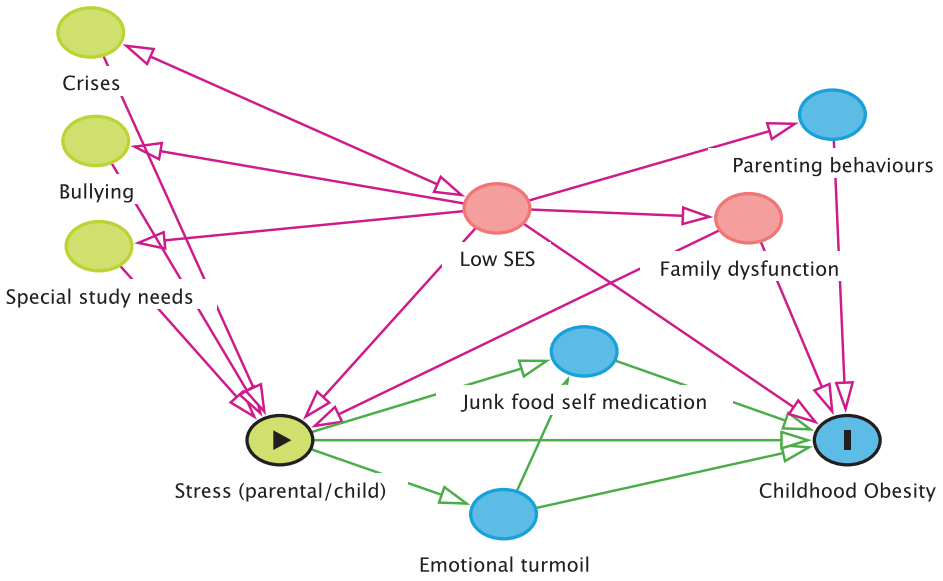


Figure 6:1 *Connections and mediators between stress (parental/child) and childhood obesity. DAGitty-model; exposure, outcome, ancestor of exposure, ancestor of outcome, ancestor of exposure and outcome, causal path, biasing path (Inspired by Russel et al. 2016, Stavrou et al. 2017, Hemmingsson et al. 2018 and Miller et al. 2018).*

6.2.2.2 School-related factors

The results from this study utilizing health care recordings from primary school years, reflected the previously recognized association between weight status and bullying (Griffiths et al. 2006, van Geel et al. 2014). Earlier studies have primarily compared children with normal weight to children with overweight or obesity; some studies having found an association only between bullying and obesity (Griffiths et al. 2006, Lumeng et al. 2010). The present study identified a difference between overweight and obesity and indicated that a greater proportion of children with obesity had experiences in being bullied, as compared to children with overweight.

Gender differences in the association between childhood overweight and experiences in being bullied have gone unnoticed in many studies (van Geel et al. 2014), although they have been identified among adolescents (Brixval et al. 2011, Koyanagi et al. 2020). Gender differences are supported by the finding that primary school boys with experiences of bullying, unlike girls, transition at a higher rate from overweight to obesity and at a lower rate from overweight to normal weight. The forms and definition of bullying and the cohort studied potentially influence the results.

The direction of the association is undefinable from this cohort study, yet the phenomenon is probably bidirectional. Boys with obesity might have been more prone to bullying, or vice versa, bullying increased the possibility of obesity and decreased the possibility of remission from overweight. Low self-esteem and poor body image are potential mediators between obesity and bullying and have been associated with bullying independently from obesity (Brixval et al. 2012, Reulbach et al. 2013, Hill 2017). Furthermore, obesity and low self-esteem have been shown to precede bullying (Griffiths et al. 2006, Lumeng et al. 2010, Reulbach et al. 2013). When making assumptions of the direction, it is noteworthy that negative influences of obesity on self-esteem accumulate (Hill 2017) and associations between these three elements remain complex.

In this study cohort 18% of the children had special study needs, whereas the corresponding figure stands at 9% for all Helsinki primary school students in 2013

(Vipunen - Education Statistics Finland 2013). This thesis additionally showed that children affected by obesity had more frequently special needs in studies than children affected by overweight. These findings point to a potential relationship between special study needs and overweight and obesity.

Studies on the association of special needs in studies and overweight are somewhat scarce. Schoolwork-related exhaustion was associated with overweight among 8th and 9th graders in Finland (Mäki et al. 2019a) and difficulties in learning have been associated with obesity. These studies used varied terms and interpretations; "academic achievements" (Faught et al. 2017, Martin et al. 2017), "school achievements" (Kautiainen et al. 2009), "educational achievements" (Han et al. 2011) and "ability to learn" (Jirout et al. 2019).

The association of lower academic achievements to obesity has been shown with adolescents but not with primary school children (Faught et al. 2017, Martin et al. 2017). Lifestyle issues or negative psychosocial consequences of obesity are potential mediators (Faught et al. 2017, Martin et al. 2017). For example, a healthy diet and regular meals is related both to learning (Jirout et al. 2019) and obesity (Jääskeläinen et al. 2013, Mäki et al. 2019a).

The likeness of these factors, special needs in studying and academic achievements, is challenging to determine as high or low academic achievements can be brought about with a widely varying amount of support. Therefore, our results can be connected to previous conclusions by assuming that children having special needs in studies during primary school will have lower than average academic achievements later. Also, an unhealthy lifestyle, a possible mediator, may affect academic results to a greater extent during teenage years. In this study, special study needs were more common among boys and the association of study needs with weight development (latent classes and transition rates) was seen among them. Boys could be more susceptible to the effects of lifestyle factors or the identified relation between boys with obesity and bullying could be influencing the results (Martin et al. 2017).

Consequently, sustaining a healthy lifestyle with adequate physical activity, enough sleep and regular eating habits, as well as preventing bullying, are optimal ways to

endorse wellbeing and support learning for school age children, regardless of their weight status.

6.2.3 Screening of overweight and obesity in school health care

School health checks, especially ones performed by school nurses, actualised satisfactorily among our study cohort. Therefore, the chances for identifying those with overweight or obesity or in risk of obesity remained favourable. According to EHR free text entries, school nurses and physicians identified children with overweight and obesity well. This has not always been the case in primary care settings in other countries (Patel et al. 2010, O'Connor et al. 2013, Chelvakumar et al. 2014). Still, obesity diagnoses were set seldom, and obesity identification often failed to trigger the making of an actual treatment plan. Similar findings have been seen elsewhere (Patel et al. 2010, O'Connor et al. 2013). Setting diagnoses seems to be related to better treatment (O'Connor et al. 2013) and enables evaluating health care processes.

Possible barriers to the implementation of obesity interventions are multiple, and they are extremely important to identify (Schalkwijk et al. 2016, Schroeder and Smaldone 2017). The present study was unable to answer questions on other barriers than the lack of parental presence at appointments. According to earlier studies, it can be assumed that bringing up weight related issues is considered difficult; parents could be unwilling to receive support or professionals may assume that parents are unmotivated. Professionals could also feel overloaded or experience a lack of suitable interventions to offer (Chelvakumar et al. 2014, Thorstensson et al. 2018). Plus, the weight stigma is adversely affecting the quality of life of children and the encounters in health care (Pont et al. 2017). Other problems in life of the child or family might furthermore be seen more important at the moment and, as a result, obesity issues may be downplayed.

6.2.4 Obesity prevention and treatment in school health care

Preventions and treatments of obesity overlap. The need for population-level primary prevention of childhood obesity is accepted world- and nationwide (Report

of the Commission on Ending Childhood Obesity 2016, Obesity in children adolescents and adults: Current Care Guidelines 2020) and prevention calls for population-level interventions (National Obesity Programme 2012-2018). Secondary prevention of childhood obesity, implying targeted actions among children with identified risk factors and interventions for children with obesity, is more problematic to define for content and responsibilities related to it are challenging to distribute. Tertiary prevention includes supporting children with overweight or obesity to cope with the situation and to avoid continued weight gain. Nevertheless, all treatments for childhood obesity are proactively preventing obesity in adulthood.

According to the results of this thesis, overweight-related extra visits to school nurses, in addition to annual health checks, were organised for most of the children with obesity and the visits were logically related to observed overweight trajectories. However, the true need and benefits of these appointments sets questions as children were without their parents at almost all of the extra visits to school nurses, and at half of the ones involving physicians. Comparison to other countries is challenging, as the possibility for a child to have an appointment alone with a physician is uncommon. According to Current Care Guideline (Obesity in children adolescents and adults: Current Care Guidelines 2020), obesity treatment should be family centred. Co-operation and discussions with parents, as well as treatment plans based on the resources of the family, are the basis for treatment.

In this study sample, between the extensive health checks performed at grades 1 and 5, children with obesity were extremely seldom sent to school physicians due to obesity. The reasons could be varied, one potentially being the lack of sufficient physician resources that can be targeted per identified needs (Hakulinen et al. 2018). School physicians could be a more useful resource for obesity prevention and treatment (Bhuyan et al. 2015), and the role of school physicians and priorities of their tasks call for further debate.

The results of this thesis showed that interventions were offered mainly to children with obesity and less to those gaining weight, even though earlier studies have indicated that obesity treatment results are modest (Mead et al. 2017) and EASO recommends early recognition and intervention (Farpour-Lambert et al. 2015).

Therefore, societal actions strengthening primary prevention and moving from treatment to targeted secondary prevention are recommendable. It can be deducted that obesity prevention and treatment should be able to 1) prevent childhood obesity from continuing to adolescence and adulthood, 2) detect risk factors for obesity development later in childhood among children with healthy weight and 3) enhance lifestyles and build a healthier attitude towards food and eating for all children and families.

Although most adolescents with obesity will also be affected by obesity in adulthood, most adults affected with obesity lack a childhood obesity history (Juhola et al. 2011, Simmonds et al. 2016). Therefore, it has been speculated whether obesity and overweight treatment in childhood is necessary or effective when counteracting on the obesity epidemic (Simmonds et al. 2016). All the three levels of childhood obesity prevention should also be seen as preventing adulthood obesity and as an endeavour to prevent mental and physical health problems in child- and adulthood.

Dietary and physical activity interventions targeted at preventing childhood obesity can make an impact and, to add to that, they appear to be detached from health inequalities and other adverse effects (Brown et al. 2019). In early care and educational settings, multi-level and multi-component interventions may spawn positive results especially in conjunction with parental engagement (Ward et al. 2017). Similarly, concomitant involvement of home and the surrounding community is beneficial for school-based obesity prevention interventions (Wang et al. 2015). Obesity prevention will benefit from the current obesogenic environment shifting towards a more health promoting one. Additionally, changes in food or physical activity environments might, in all age groups, ameliorate the results of interventions treating obesity.

School health care offers a platform for meeting children widely and regularly, and therefore has potential for enhancing the health of children and their families at large. The present decree stipulates the organisation, for all children, of annual health checks and, additionally, two extensive multidisciplinary health checks during the primary school years (Government decree 338/2011). In addition to

promoting health, the aim is in identifying children and families in need of special assistance and in organizing support for them.

This Finnish policy of annual health checks enables to follow weight development and find possible aspects behind adverse trends. However, the checks consume time from school nurses, as do the extensive health checks at grade 1 and 5 from school physicians. Therefore, benefits of especially the untargeted health checks by school physicians have been discussed, supported and criticised (Nikander et al. 2018, Hietanen-Peltola et al. 2019, Kosola 2020). The difficulty of balancing between demands and with limited resources has been discussed and speculated; how can school health care simultaneously offer sufficient general health promotion as well as targeted support for individuals with identified special needs. Efforts of obesity prevention and treatment should always be allocated wisely, be it in conjunction with untargeted or targeted health checks.

For obesity prevention, the ability to identify children likely to develop obesity, other who will remain obese without remission and ones naturally dissolving obesity without intervention, represents both a considerable challenge and an opportunity. Present knowledge points to remission before adulthood being the key to later cardiovascular health (Juonala et al. 2011b, Buscot et al. 2018b, Bjerregaard et al. 2020b). The increasing awareness on the subject could help in targeting school health care resources better, at least as far as obesity prevention is concerned.

6.2.5 Timing and targeting of health checks and obesity related interventions in school health care

Almost all 5th graders of the study sample attended health checks performed by school physicians. However, only half of the 1st graders attended their equivalent checks, most probably due to lack of sufficient school health care resources. Obesity seemed unrelated to the cut of 1st graders, as, out of them, only 58% of the ones with obesity met a school physician. For some, the decision could have been made watchfully, but nevertheless weight status by itself seemed to be unrelated with attendances to 1st grade school physician appointments.

Arguments on optimal timing of obesity prevention and treatment remain multiple. Weight management of the former generation stands as the earliest alternative (Gillman and Ludwig 2013), due to the pre-pregnancy weight status of the mother having implications on the health and weight development of the child-to-be (Woo Baidal et al. 2016, Leonard et al. 2017). Early life is the next of moment suggested, as risks for obesity can be seen already then (Woo Baidal et al. 2016, Buscot et al. 2018a, Moreira et al. 2019, Juonala et al. 2020). Counterarguments have been raised, noting a finding that up to 40% of overweight and obese 4-5-year-old children were normal weight at 10-11 years of age (Wheaton et al. 2015). Similarly, the results of this thesis showed that 30% of children affected by overweight or obesity before school age were in normal weight area over primary school. The earlier mentioned change of the cut-off from 10% to 20% could in part explain the finding.

As the prevalence of overweight increases from preschool age to school age (von Kries et al. 2012, von Kries et al. 2013), it can be argued that interventions should be targeted at the first primary school years. Additionally, adolescence has been offered as the best time to intervene as before that there is a higher probability for remission (Simmonds et al. 2016). Youth age offers a receptive phase for secondary prevention as natural resolution of youth obesity seems to occur in late adolescence for girls and in early adulthood for boys (Buscot et al. 2018a). Argumentation on choice of timing needs to be associated with optimal, delicate and age-appropriate ways to intervene and support the child and family without causing psychological disturbance or other side effects. The best timing seemingly varies between individuals and care is needed in identifying the optimal moment.

Both children and adults, regardless of their weight, benefit from embracing healthy attitudes towards food, eating and their own body (Voelker et al. 2015). In addition to supporting this for every child and at all ages, a logical goal could be to react as soon as possible when children and families are identified as having a high probability of developing and persisting obesity. Moreover, preventing obesity during adolescence and targeting for normal weight before adulthood can have an important effect on cardiovascular health (Juonala et al. 2011b, Buscot et al. 2018b, Bjerregaard et al. 2020a).

Weight, BMI or even BMI SDS observed solely at a definite moment is insufficient for interpreting the growth and health of children. Classification to weight categories of normal weight, overweight and obesity is even more so, as the classifications vary significantly between growth references, age and gender (Butte et al. 2007, Mäki et al. 2012, Nilsen et al. 2016). Therefore, longitudinal data of the child's weight development is useful for targeting interventions to those who will benefit the most, especially when complimented with other predictive factors (Ziauddeen et al. 2018, Juonala et al. 2020, Welten et al. 2020).

Past weight development augmented with knowledge of typical overweight trajectories and probabilities of weight transitions offer additional information for targeted interventions. Risk assessments become more precise along age. A possible history of gestational diabetes of the mother should be utilised as an early risk-factor for childhood overweight (Hakanen et al. 2016). At the age of entering school, a risk assessment can be made by utilising, in addition to the weight status of the child, knowledge on maternal BMI and education level (Juonala et al. 2020). Furthermore, adding social disadvantage variables to the risk assessment could be useful (Juonala et al. 2020). The BMI and education level of the mother are not regularly recorded in Finnish EHRs, against the presumptions of this study. Yet this information is available at the time of the appointments, when parents are present. Unfortunately, parents attended just half of the overweight-related school physician appointments and very seldomly at nurse appointments. Fortunately, factors related to learning and getting along in the school environment are available from EHRs.

Utilising the knowledge of family- and school-related characteristics associated with unfavourable weight development over primary school, primary school age seems to offer a potential moment to intervene. Preventing obesity development, especially in low SES families, presumably decreases health inequity (CSDH 2008). The weight status of the parents, earlier weight development of the child, family structure and possible experiences of crises or bullying seem to offer crucial information on the probability of childhood obesity development.

6.3 Methodological considerations

6.3.1 Inclusion criteria and weight assessment

This thesis utilised manually collected retrospective EHR register data of weight and height measurements. Both weight-for-height and BMI-for-age references were adopted for the assessment of weight development. The choice made between these Finnish references and international references (IOTF and WHO) is open for speculation. The main research question, how school health care professionals screen and treat overweight and obesity, lead to selecting the study sample by using weight-for-height references, as it was the sole approach used in clinical practice at the time. The Finnish BMI-for-age references (Saari et al. 2011) came into use later and offered sex- and age-specific BMI SDS figures for utilisation in novel growth development analyses.

The weight-for-height references have limitations which disregard children's age and define overweight and obesity separately for over and under 7-year-olds. This physiologically artificial step change produces a situation where a child could switch from overweight to normal weight or from obesity to overweight overnight when turning seven. Some of the children of this study who were under 7 years of age at the time of their 1st grade health check would have been classified differently had the check been carried out a bit later.

The goal of the study was to identify observable factors which could be considered in school health care work for preventing and treating obesity. Initially the children were selected for the study according to the weight-for-height references utilised in primary health care in Finland. Later, when analysing growth development patterns and transition rates, BMI-for-age references were employed and only children with overweight in accordance to them were included. Therefore, in Studies III and IV, the classification came to be a mixture of both references. The use of various international and national growth references in research poses challenges and complicates international comparison. However, assumingly in many studies, such as this one, the aim of the study could steer away from international references.

As Figures 5:2 and 5:3 earlier displayed, and similar effects having also been seen in prior studies (Butte et al. 2007, Mäki et al. 2012, Nilsen et al. 2016), all the three abovementioned growth references classified children of this study sample somewhat differently, producing variation by gender and age. The IOTF references would have classified more of the girls and less of the boys as having obesity, when compared to the Finnish BMI SDS classification. In the latter classification, a greater proportion of primary school girls were classified as normal weight compared to the IOTF and weight-for-height references. For boys, differences between weight classifications dissipated at the middle of primary school resulting to all three references classifying the boys identically after their 4th grade.

In a similar fashion, different growth references cause challenges to clinical work. Currently both weight-for-height and Finnish BMI-for-age references are used jointly in Helsinki, and both are recommended to be applied for children over 2 years of age by the Current care Guideline (Obesity in children adolescents and adults: Current Care Guidelines 2020). In some cases, the references deliver differing classifications. This highlights the importance of longitudinal data in defining cut-offs (Kartiosuo et al. 2019) and clinicians observing overall weight development rather than weight classification at a certain point in time.

The decision to include individuals with even a single overweight or obesity measurement into the overweight or obesity categories was also based on the research question on how overweight measurement events are handled in school health care. A demand for a minimum of two overweight measurements per child could have resulted in the study sample being a more uniform group of children, leaving out those just having visited the overweight area.

6.3.2 Analysis of weight development

In the course of the data analysis, novel Finnish BMI-for-age references were used conjointly (Saari et al. 2011) in order to scrutinize weight development and study BMI along age. BMI SDS has shortcomings in showing BMI changes during adolescence and in cases of severe obesity (Juliusson et al. 2018). Nevertheless, in this study sample consisting of primary school children and hardly any children in severe obesity area, BMI SDS was considered suitable.

Had this study only used distinct values such as the highest or lowest weight-for-height measurement or the absolute weight change from 1st to 6th grade, the children's actual weight development would have remained obscured. Having multiple, albeit a varying count of, measurements per child had the potential to produce more understanding. Therefore, in order to profoundly describe the change over time, we applied novel statistical methods; Latent class mixed models and Markov multistate models. Both methods have numerous restrictions and data requirements, yet after careful consideration using earlier published guidelines and with the aid and expertise of a biostatistician, suitable models for the data could be formed.

6.3.3 Screening and treatment practices

This study aimed to evaluate screening and treatment practices of school health care personnel at every primary school grade, in the context of annual and multidisciplinary extensive health checks. Therefore, the EHR data were compiled school grade by school grade. This enabled forming descriptive data of screening and treatment practices actualized in different stages of the school health care health check protocol. Still, this challenged some of the analyses as the age of the children differed in the same school grade. Courtesy of using longitudinal data, combining all information from primary school years was possible. Variables such as *Optimal Intervention* or "treatment plans offered or actualised after the child had been noticed overweight or obese for the first time" were achievable. Yet, timing of single interventions remained inaccurate and did not allow for their analyses in relation to weight changes.

6.3.4 Family- and school-related variables

This study examined only the victimization of bullying, not the perpetrators. The presumption was that, while data on victimization is obtainable, health records most probably lack information associated to perpetration. All health checks should include discussing bullying (Government decree 338/2011) and fortunately, according to this study, and at least to some degree, children were willing to share stress related to bullying with health care professionals. However, EHR recordings on bullying indicated that it might have been easier, at least for some children,

to speak about it afterwards as in "were bullied last year / earlier in lower grades but not bullied anymore". The conclusion was that a single entry at a single school grade lacked needed information. Therefore, data from all six school grades were collected and combined into a single variable indicating had the child been bullied or not during primary school.

The aim was to collect data also on learning and school achievements from EHRs, but this turned out to be problematic. An often-used entry "school is going well" seemed to imply a variety of matters. When multidisciplinary work is required, information of the school performance of a child, deeming permission of the student and her parents, is shared among teachers, school welfare team members and school health care to facilitate multidisciplinary efforts (Student Welfare Act 2013). This valuable sharing of information for potential capitalization in school health checks has been identified earlier and the Finnish Institute for Health and Welfare (THL) has launched a procedure to facilitate it (Opiskeluhuollon lomakkeita 2019). The procedure hopefully conveys to both parents and pupils that health and school performance are interrelated and need to be considered as an entity.

It is customary during health checks to record specialised support receive by children for their studies. So, instead of forming a variable representing learning, data were collected on special study needs over primary school. This information was converted to a dichotomous variable, as disclosed earlier in Subjects and Methods chapter. Although needs for support in studying and learning abilities are not directly comparable with each other, they offered a practical means of evaluating the school performance of children. Information on special support was reliably reported and readily available in EHRs, in contrast to the factual school achievements.

Some of the variables gathered from EHRs could have been collected in a better way, yet this could be recognized only after having gone through the EHRs and learned what data is reachable and to what extent. For example, data on school achievements and support needed and received, as well as data collected on family backgrounds, needed later reorganisation in order to form reliable variables. Additionally, records of health habits, eating, sleeping and physical activity were

abundant yet unorganised and therefore their use as variables had to be rejected. This is logical as the data has been entered for clinical use, instead of research purposes. It can be expected that data in EHRs will evolve towards increasing structure and therefore be better exploitable.

6.4 Strengths and limitations

6.4.1 Strengths of the study

This study utilised real-life register data from EHRs of a random sample of 6th graders in Helsinki. The study being limited to a single city restricts the generalisability of the results. Although the study sample size was only moderate, the coverage was broad as the whole 6th grader population of Helsinki was available for the random sample. The results can be universalized to other Finnish urban areas and cautiously for other countries having similar coordination of school health care. By this, a possible selection bias and drop-outs could be avoided. Additionally, data from EHRs offer a way to analyse actual day to day work of school health care professionals, not just their own expectations or assumptions of their work (Chelvakumar et al. 2014). Furthermore, delving into all recordings, instead of simply gathering assessed diagnoses for obesity, offers a fresh perspective on the screening of overweight and obesity.

The decree for school health care services in Finland (Government decree 338/2011) gives guidance on performing universal annual health checks (Table 2:3), making annual growth measurements of all children without special study arrangements largely available. Also, many children participate in additional appointments, which spawns more measurement points and offers supplementary information. Customarily school nurses request earlier health care documents and growth measurements from children moving in from other cities, entering them into EHRs. Consequently, some growth measures assessed prior to moving into Helsinki were available for the study. Statistical methods used allowed exploiting all available growth measurements, regardless of their timing or quantity. Without a need for, for example, selecting the closest measurement to a certain age, a more detailed picture of a child's weight development may have been gained.

In many studies, the work of school physicians and nurses have been examined independently (Patel et al. 2010, O'Connor et al. 2013, Schroeder et al. 2016). School nurses and physicians work as a team in Finland and the distribution of tasks may vary between professionals. Therefore, in this study, the work of school nurses and physicians were mostly combined in order to recognize the overall actions taken in school health care.

Overweight development, often likewise to its treatment, is a lengthy process. Therefore, the longitudinal set-up utilized provided advantages over cross-sectional studies of single appointments where information on interventions offered at adjacent appointments is lacking. Furthermore, by utilising school health care data, followed processes and treatments offered could be analysed school grade by school grade.

6.4.2 Limitations of the study

Real-life EHR recordings have their limitations as sources of research data. Recordings may include unrealised interventions or actualised interventions could evade recording (Turer et al. 2017). Still, as the aim of the study was to find factors associated with overweight development and identifiable from EHRs, this potential discrepancy remained limited.

Information bias should always be considered. Children with obesity might have been interviewed more meticulously, causing a surveillance bias. Still, as children and their parents fill out nationally approved inclusive questionnaires (Opiskeluhuollon lomakkeita 2019) before most health checks, psychosocial variables utilised in this study should be available just the same for children with overweight and obesity as for all other children. Growth measurements utilised in this study have been observed and entered in EHRs by numerous health care professionals over a time span of six years, which may result in an observer bias.

As the aim was to collect data on overweight development and overweight-related interventions, EHRs of children with normal weight were not examined. Due to this, children with overweight and obesity could not be compared to children with normal weight. Such data could have offered possibilities for additional research

questions yet was seen unachievable with available resources. Every EHR needed to be accessed and growth measurements examined for all the 2000 children, on top of this the harvesting of data for the 574 children with overweight took from 30 minutes up to 2 hours per child.

Acquiring clues of the weight status of parents, especially maternal BMI, as well as the SES of the family and education level of parents would have been valuable. Unfortunately, this information was mostly unavailable from primary health care recordings. Some health care professionals had entered parental occupations or education levels in free text fields, but data on SES was largely unavailable. Regulations allow and, in fact, require recording factors that are relevant for treatment, yet data protection regulations ban entering information into EHR on other persons' health issues (Act on the Status and Rights of Patients 785/1992, General Data Protection Regulation (GDPR) 2018).

This study noted that the family health issues and diseases which ended up in EHRs of children were either free text or in regular child health clinic entry fields. Markedly, weight issues of the family or relatives were never recorded in the same entries as other family risk factors and very rarely mentioned in free text. On the other hand, for the eight children having been referred by school physicians to paediatric outpatient clinics, paediatricians never failed to enter information on parental weight status or BMI into their outpatient medical records. On these grounds it seems that privacy regulations, essential as they may be, and aims for inclusive childhood obesity risk evaluations are contradictory to some extent.

7 CONCLUSIONS

In addition to the interim weight status of a child, primary health care EHRs provide individual information related to weight development. Studying overall weight development pays more than just examining the momentary weight category, of which the latter depends on the reference adopted. In the context of school health care interventions, weight development of primary school children has not been studied earlier by utilising latent class trajectories or probabilities of transiting between weight categories. Typical overweight development patterns can be distinguished and the probabilities of transiting between weight categories are associated with family- and school-related factors.

Still, some important predictors lack data entry fields in EHR templates. For example, parental BMI and data on SES are seldom available. Data on parental height is routinely recorded and automatically inserted into growth charts of children. However, information on parental weight is absent, although the data would be useful for clinicians supporting children's health, for preventing obesity and for directing health care efforts wisely. Privacy policies and individual styles for EHR data entry both hinder development of this issue. On the other hand, in this study, family- and school-related factors were available in EHRs and they were, importantly, confirmed to be related to obesity development. Parental and offspring stress could, in part, mediate the relations, with SES presumably affecting in the background.

School health care personnel seem to offer interventions mainly for children with obesity. It could be more fruitful to concentrate on individuals who are gaining weight and those with an observed risk of obesity or with a reduced likelihood for natural remission. Still, all of these approaches demand sensitive discussion and successful co-operation with families; here barriers remain. These challenges need not only to be worked on by individual health care professionals, but changes to school health care processes, probably also structures, are called for.

The continuity of obesity into adulthood can obviously be prevented by preventing childhood obesity. Weight gain during adulthood could also be deterred by encouraging all children and families towards healthier lifestyles and by supporting physical and mental wellbeing. On top of this, obesity preventions and treatments

can enhance wellbeing already during childhood. Therefore, diverse intervention approaches are called for; ones aimed at the population at large and others specifically to children at risk.

The aim of this thesis was to identify potential development areas in school health care obesity prevention and treatment. According to the results, the extensive multidisciplinary school health checks now done at 5th grade should be organized either at an earlier age or in a more targeted manner by paying attention to the unique situations of the children and their families. As parents were seldom present at appointments, novel models of co-operation with parents are required. The Covid-19 pandemic has forced health care to take a digital leap (Rissanen et al. 2020). The recently introduced remote contact tools will assumingly be beneficial also in the future. For example, remote appointments with parents could boost co-operation with parents.

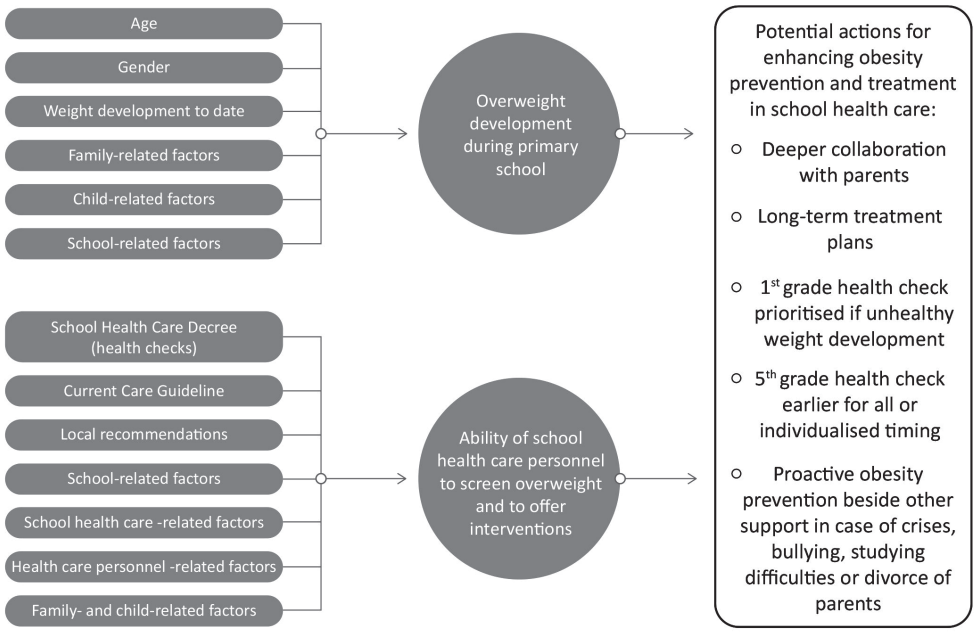


Figure 6:2 *Potential actions for improved obesity prevention and treatment, according to this thesis*

8 IMPLICATIONS

8.1 Implications for future research

The outcome of this thesis can be exploited for planning intervention studies. According to the results, gender differences are meaningful and could do with further exploring. Girls with obesity seemed to have two seemingly different weight development trajectories and therefore the results of interventions might differ between these two subgroups. Furthermore, the associations of family- and school-related characteristics with weight development depended on gender. A hypothesis can be made that gender-specific interventions, both for prevention and treatment, are more effective than universal ones, as the development of overweight and associations with psychosocial characteristics differ between girls and boys. Additionally, it could be worth exploring whether childhood obesity risk models, including earlier weight development, early-life factors and parental BMI, could benefit from the addition of some of the family- and school-related characteristics studied here.

By using latent class analysis methods with larger populations and longer follow-ups, additional information could be obtained on childhood overweight development, especially of its continuity. Furthermore, if received treatments can be dated more precisely and compared with weight trajectories, the effects of treatments of different subgroups could be analysed. Knowledge on the association of bullying and transition rates between weight categories could also be utilized with other studies and interventions in order to reduce bullying.

If prevention and treatment practices of school health care in countering obesity were more structured, yet still individualised, also the EHR entries might be more uniform. Structured EHR data from the new Finnish regional health care information system Apotti (Apotti-project 2012), might help in gathering research data. The FinnLapset-register of the Finnish Institute for Health and Welfare is being developed and, along with growth measurement data, begin to include children's school health check data from the Avohilmo-register. When evaluating which components from EHR's to utilise, the identified associations of family- and school-related characteristics and weight development should be weighed in.

8.2 Clinical and policy implications

Deducing from the results of this thesis, some suggestions were made for advancing obesity prevention and treatment in school health care. Table 8.1.

Table 8:1 *Suggestions for organising obesity prevention and treatment in school health care*

Suggestion	Argument	Assumed benefit
Develop health care processes supporting early identification of excess weight gain and sensitive intervening	Professionals see intervening important, yet obstacles remain Weight stigma makes intervening difficult Sensitive intervening is challenging, yet achievable and possible to master	Children and parents can be supported with lighter and shorter interventions than at later stages of obesity Families and professionals will both benefit Cost savings
Investigate the possibility of regularly recording parental BMI, or at least some mention of their weight status, into primary health care EHRs	Important for risk evaluation Personal data should not be entered to another person's EHR, yet according to the Act on the Status and Rights of Patients (785/1992), "health care professionals shall record on patient documents the information necessary for the arranging, planning, providing and monitoring of care and treatment for a patient" Paediatricians in outpatient clinics enter this information into patient records, making it potentially possible also in primary health care Information on significant risk factors should be included in EHR as a single entry	Children with higher risk for obesity can be identified and supported early on

Assess individual risks by using all known predictors, thus affecting the treatment and follow-up plan of the child	Single point growth measurements or knowledge on weight category are clearly unable to predict future health of children Prediction models have been improved	Limited resources can be utilized wisely, maximising health benefits
Form far-reaching treatment plans together with parents	Parents are the most important stakeholders. Initial holistic discussions and far-reaching plans overcome the tendency of the topic being brought up repeatedly by different actors	By setting, together with parents, follow-up and treatment plans with a longer perspective, the co-operation with parents can be assumed to strengthen, use less effort and may enable better treatment results
Develop co-operation with parents and school health care	Parents need advanced and modern ways to interact with school health care professionals	Children and families will benefit, and professionals may feel their work to be more meaningful
Enter diagnoses of obesity into EHR when criteria are met	To further develop school health care services and for planning training for school health care professionals, it is important to notice that the identification of overweight and obesity actualizes well, yet barriers for setting diagnoses continue to exist	Diagnoses included as structured entries enable regular analyses of screening success, which is needed for ameliorating current processes
Move multidisciplinary 5th grade extensive health checks to 4th grade or time them according to children's individual needs	The findings of this study support the argument for holding multi-disciplinary health checks around age 10, a year earlier than the Decree guides. Evidence-based risk assessment at that moment, at the latest, could be beneficial	Children and families receive support for overweight-related and other health issues when they need it, not only at predefined age or school grade

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